THE TECHNOLOGICAL ECONOMICS OF COLLECTION AND LANDFILL DISPOSAL OF MUNICIPAL WASTE IN THE UNITED KINGDOM

by

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APPENDICES

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APPENDICES

The appendices are arranged in the order of the chapter they accompany in the text, where two or more appendices are referenced in one chapter these are presented in alphabetical order, i.e. 3A, 3B, 3C.

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APPENDIX ACCOMPANYING CHAPTER 2

APPENDIX 2A

Some topics for further study in the Collection of Municipal Waste

APPENDIX 2A

Some topics for further study in the collection of Municipal refuse

1. Compaction values achieved by different compacting equipment and methods with particular regard to the effective elimination of voids from refuse within the vehicle body.
2. The physical state of refuse under different compacting methods.
3. Short term (ie. within one week) biological, chemical and physical changes occurring in refuse.
4. Chemical and physical effects on dustbins resulting from interactions with constituents in the refuse, mis-handling by collectors and householders or from extremes of temperature.
5. Further study on pipeline disposal systems using water or partial vacuum since only a few of these are near or at the stage of commercial use.

The Working Party on Refuse Storage raised other issues on which collection research was, and still is, lacking:

1. Studies to reduce noise from compression and loading mechanisms on vehicles;
2. Fly control and hygiene in storage;
3. All aspects of collection operation costings;
4. On-site compression techniques;
5. The movement of refuse in and from large buildings.

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APPENDICES ACCOMPANYING CHAPTER 3

APPENDIX 3A

This appendix contains a detailed review of the arguments by proponents and opponents to pulverisation of municipal waste. It is based upon the conflicting views taken by each school of thought over the generally reported advantages and disadvantages in Section 3.5.2

3A.1 VOIDS AND VOLUME REDUCTION

The comminuated nature of pulverised refuse reduces the number and sizes of voids within the landfill which, when compacted, produces volume savings of up to 34% (DOE, 1971). This is compared in further detail with tracked and rubber-tyred vehicle emplacing untreated refuse in Tables 3A.1 and 3A.2. Reinhardt et al (1974) found that no improvement in densities were achieved when compared against those of steel-wheel compactors. For wet pulverised refuse he quotes a volume saving of 18% over compactors. These initial improvements in density are likely to be reduced when one considers that on sites it will be sometime before there is emplacement at the present point on the next lift. During this intervening period, untreated refuse will decompose down at a faster rate than the more tightly packed pulverised refuse, hence reducing the density difference considerably.

The absence of voids reduces settlement. Marsden, (1973) claims pulverised landfills can be developed as little as two years after completion. Observations by others disagree suggesting a minimum of five years; comparable to untreated refuse.

3A.2 SITE LIFETIME AND COVER REQUIREMENTS

The overall effect of the reduction in voids and improvement in refuse densities is to extend the site lifetime. NCRR (1974) estimate between 0 and 15% depending on the emplacement vehicles and technique employed. Further increases on site lifetime can be obtained if cover is estimated. Advocates of pulverisation claim cover is not required on treated refuse thus saving up to an additional 33% of airspace (Skitt, 1972). This factor also increases the number of potential sites in a given area by enabling those

	Sumner (DOE, 1971) (1) (2) Density after initial consolidation (tonnes/m^3)	Loram (1976) (2) Density after initial consolidation (tonnes/m^3)
Pulverised Refuse	0.904	0.850
Untreated Refuse	0.598	0.660
For a given tonnage:- Percentage increase in volume for pulverised refuse landfills	33.8%	22.4%

(1) Result based on only 1 plot of pulverised refuse and 1 plot of untreated refuse.

(2) Not stated if density value includes the weight of cover or otherwise in its derivation. Assumed cover is included therefore "density" should read "actual density". An explanation of these terms is given in section 3.8.

Table 3A.1 An investigation into the initial consolidation of pulverised and untreated refuse at a landfill site in Wetherby carried out by the Working Party on Refuse Disposal - Sumner Committee (after DOE, 1971) and estimates by Loram (1976).

(tonnes/m^3)

	Actual Densities *		Effective Densities *	
	Wet	Dry	Wet	Dry
Pulverised Refuse	0.758 - 0.845	0.472 - 0.554	0.718 - 0.800	0.456 - 0.524
Untreated Refuse	0.664	0.481	0.593	0.430
For a given tonnage:- Percentage increase in volume for pulverised refuse landfills	12.4 - 21.4	$^{-}$0.84 - 13.2	17.4 - 25.9	5.7 - 17.9

Table 3A.2 Densities based on settlement tests undertaken by Reinhardt et al. (1974) at Madison, Wisconsin.

* Explanation givn in section 3.8

locations to be considered where no on-site or near-by cover material is available (Rimberg, 1975).

Furthermore, the absence of cover enables any gas produced during decomposition to be easily dispersed and so reduce the dangers of accumulation (Ham, 1975). Conversely, the DOE (1971) recommends that 15cm of daily cover should be used on pulverised refuse, the same as for untreated wastes. NCRR (1974), adds that cover may still be required for aesthetic reasons or to minimise infiltration from surface rainfall and surface run-off. Some cover is also required to stabilise the tip surface so as to reduce the likelihood of punctures and improve mobility of site plant and discharging vehicles.

3A.3 PESTS AND FIRE RISK

The mixing of wastes in treated refuse renders the food component unpallatable to pests and consequently nuisances from flies, birds and rats are less likely to develop. Pests, although reduced, are not entirely eliminated from the landfill (Reinhardt et al, 1975). Opponents to pulverisation point out that control of pests while necessary, is not a limiting factor to a direct landfill's operation, particularly when daily cover is used.

Similar points can be made for the risk of fire on site.

3A.4 LITTER

The small diameter of the pulverised product should reduce the nuisance from wind-blown litter. However, the DOE (1971) and Loram (1976) found that this problem is only satisfactorily eradicated when wet pulverised refuse is landfilled.

3A.5 ODOURS

It is claimed that pulverised refuse does not smell at all. The DOE (1971) study has reported that a "not disagreeable" odour was detected at some landfills, particularly where a wet product had been deposited. These observations are comparable to direct landfill.

3A.6 RATE OF DECOMPOSITION AND LEACHATE

Reinhardt et al (1974) concluded from their studies that the effect of pulverisation and mixing was thought to enhance the rate of "physio-chemical leaching" and biological decomposition, by increasing the surface area of the refuse. This suggests that even if settlement rates are similar to untreated refuse, then decomposition and biochemical stabilization of pulverised material may be faster than untreated wastes. Consequently, a stronger leachate may be produced in the short-term. The Harwell Laboratory and the DOE are currently engaged in long term landfill experiments and aspects of their work are related to these points.

3A.7 SMALL-SCALE OPERATIONS

Pulverisation is not practicable for low tonnages unless buffer storage is used since the unit costs depend on a continuous supply of refuse over the working day which matches the rated capacity for the particular machine installed. Consequently, pulverisers are not suitable for isolated communities or small disposal districts (Rimberg, 1975).

3A.8 IRREDUCIBLES AND PULVERISER BREAKDOWNS

A pulveriser cannot deal with all materials, large objects, rubble, rolled carpets, wire, tree cuttings and potentially explosive substances. These must be screened out expensively by hand and landfilled directly.

Pulverisers are also subject to periodic breakdowns and maintenance for which alternative facilities or plans are necessary. These usually entail the direct landfilling of untreated refuse. Where the downtime of a plant is considered significantly large this can be a strong argument against the adoption of such methods elsewhere. The reliance of the disposal operation on one piece of fixed plant is another area of concern.

3A.9 PULVERISER DUST AND NOISE

Problems common to all transfer methods arise from the noise and dust generated by the fixed plant. These factors can adversely affect the granting of planning permission, especially if the transfer station is near residential properties. Complying with planning or industrial health regulations requires expensive modifications to the basic design of plant. Measures to reduce noise can include earth banking on those side of the site facing houses, placing the pulveriser and compactors in pits below ground level, wide cavity walls and sound insulation throughout (Cheyney, 1980).

To suppress dust, fine sprays can be located over bunkers, feed hoppers, and the inlet and outlet conveyers of the pulveriser. In the reception hall, extractor fans remove exhaust fumes and dust-lades air passing through a filter prior to discharge into the atmosphere .

3A.10 BULK TRANSPORT PAYLOADS WITH WET PULVERISED REFUSE

The addition of large quantities of water during wet pulverisation, most of which is absorbed, adds approximately 33% to the weight of the product. Where this has to be bulk transported, a weight increase of 33% must also be carried. This will serve to increase the haulage cost by requiring extra trips or vehicles. Unfortunately, there is no specific evidence in the literature on this point. Manufacturers claim that any additional transport cost is offset by the lower overall operating cost for wet pulverisation. It is also a better material to handle and there is no need to purchase or win daily cover.

APPENDIX 3B

Detailed Discussion on the Advantages and Disadvantages of Baling

Baling is said by its advocates to have several advantages over direct landfill and the other treatment methods. These are discussed here together with several shortcomings suggested by its critics. This appendix is based on the small number of published articles, manufacturers' claims and the reactions of local authority officials. However, since baling is a very recent development many of the advantages have yet to be substantiated and many of the disadvantages have yet to be clarified.

3B.1 VOIDS AND VOLUME REDUCTION

The baling of waste reduces voids by physically crushing the material. Densities achieved in a bale do not appear to depend upon the compaction pressures applied by the baler, but on the amount of springback which occurs before landfilling and the refuse composition. The typical densities of the bales produced by each baling method are outlined in Table 3B.1 and it is apparent that the so-called "high density" method of treatment actually produces bales with a lower density at emplacement than the "medium density" method.

Stone (1975) studied the springback characteristics, which only occur in self-sustaining bales, at St Paul in Minnesota and discovered that the largest expansion in volume took place within the first 24 hours (ie. 35%) (Fig. 3B.1). Later work (Stone and Kable, 1976) derived values of 7.4%, 28.4% and 24.6% for 1 hour, 1 day and 1 week respectively. Millbank (1976) suggests as much as 50% expansion overall. The composition of refuse mentioned above is also an important consideration in springback. Where ash content is high one can expect reduced springback due to the lower elasticity of this material.

The compacted state of each bale is retained on emplacement at landfill and the regular shape enables close packing at the working face. This it is claimed makes the maximum use of airspace. Opponents point out that the effective density of refuse in the landfill is not only dependant upon high bale density but also upon stacking the

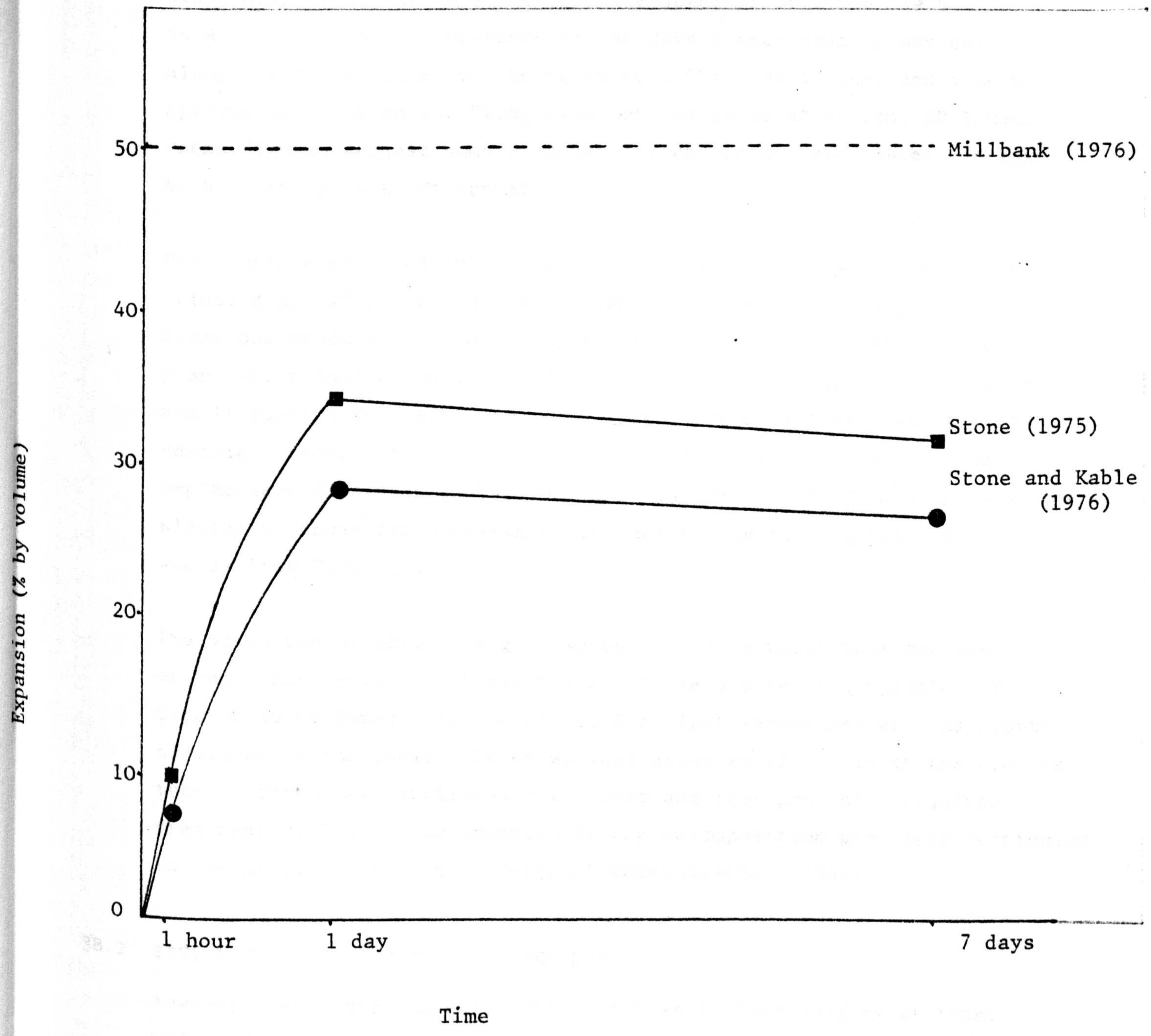


Fig. 3B.1 A graphical representation of three studies into the expansion of self-sustaining bales.

bales tightly to minimise inter-bale spaces. Irregularities in site terrain and poor emplacement by forklift operators can impair close alignment. Measurements of bale spacings by Stone (1975) in Minnesota over a nine-month period gave a mean spacing per bale along the "short side" of the bales at 2.97cm, SD 1.00cm, and a mean spacing per bale on the "long side" of the bales at 9.37cm, SD 1.99cm. These figures suggest some reasonably large inter-bale spaces are likely to be left by forklift operators.

The "emplacement density" at baled landfills is virtually equal to the "final density" and further settlement is claimed to be negligible. Stone has produced evidence to support this, at least over the first year after emplacement (Fig. 3B.2). Longer term trends are not known and if large inter-bale spaces are left differential settlement will certainly occur across the site. It should be noted, however, that the emplacement densities quoted for baled landfills (0.8-1.0t/m^3)(Table 3.B1) are similar to those for steel-wheel compactors landfilling untreated wastes (see Table 3.8).

The advocates of baling (e.g. Sowerby, 1977), suggest that the absence of voids and reduced settlement will enable a site on completion of tipping to be immediately developed for light structures such as sports pavilions or car parks. Other workers disagree with this on the grounds that differential settlement will occur and that gas which requires treatment will still be produced by the decomposition processes continuing in the landfill (Campbell, Personal Communication, 1982).

3B.2 SITE LIFETIME AND COVER REQUIREMENTS

Sowerby (1975) has suggested site lifetime is increased by at least 50% over that obtained for untreated refuse when emplaced by tracked and rubber tyred vehicles. However, if the effective densities achieved are only comparable to steel-wheeled compactors, then the increase in site lifetime over tracked and rubber-tyred vehicles will probably be no more than 20% in practice.

It is claimed that Baling does not require daily cover. This would save up to an additional 33% of airspace with the benefit of increasing site lifetime. Similar arguments, as discussed for pulverisation in

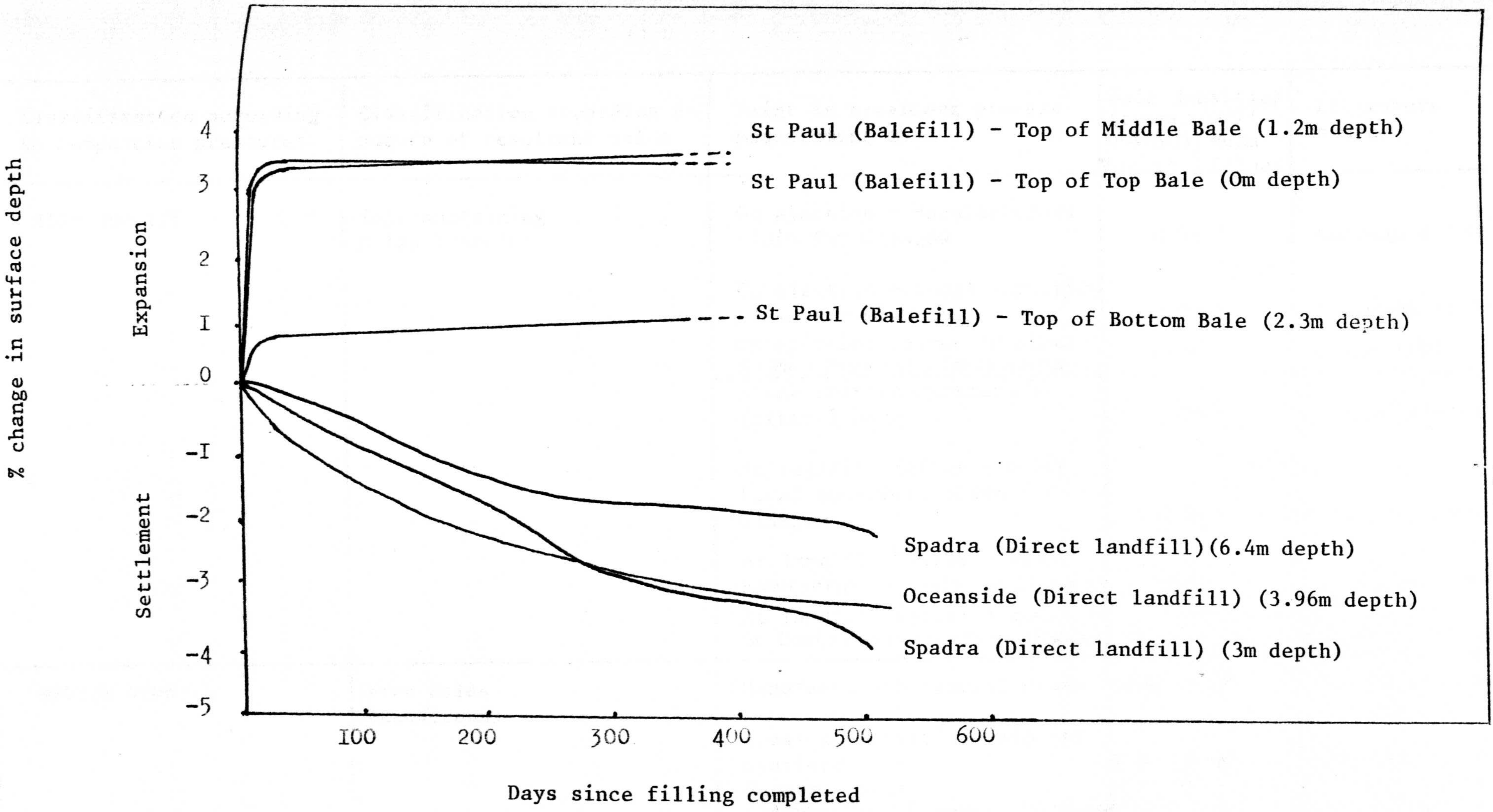


Fig. 3B.2 Short-term Expansion/Settlement trends: St Paul Balefill and Direct, Untreated Refuse Landfills (After Stone, 1975).

Classification according to compaction pressures	Classification according to nature of resultant bales	Point in treatment process measurement made	Bale densities (tonnes/m^3)(1) Individual Values	Bale densities (tonnes/m^3)(1) Mean Values	Literature source
HIGH DENSITY	Self-sustaining Bales (Amhoist)	On ejection - Manufacturers claim for Glasgow	0.96	0.88	Chapman (1980)
		On ejection - Local authority claim for Glasgow	0.88		Shephard (1979)
		On ejection (after 10 mins)- St. Paul, Minnesota (mean value)	0.80		Stone (1975)
		After initial springback (after 1 hour ?)	0.87	0.84	Wilson (1981)
		At landfill (after 1 hour) Local authority claim for Glasgow	0.80		Shepard (1979)
		At landfill (after 1 hour) manufacturers claim for Glasgow	0.94		Chapman (1980)
		At landfill (after 1 hour) - St. Paul, Minnesota - Mean (Range)	0.75 (0.73-0.93)		Stone & Kahle (1977)
MEDIUM DENSITY	Wire Bales (Lindemann)	Manufacturers general claim	app. 1.00		Lindemann Brochure (Lu 48/7.6)
		Local authority's claim for Stafford	0.9 - 1.00	0.95	Shepard (1979)
		General figure	0.8 - 0.9		Wilson (1981)
		San Diego, Calif. (Range of densities)	0.98- 1.01		Stone & Kahle (1977)
LOW DENSITY	(Amhoist)	Manufacturers claims for Musselburgh	0.87	0.87	Chapman (1980)
		Local authority's claims for Musselburgh on commissioning	0.86		East Lothian DC (1980).
	(Vickers Logemann)	Manufacturers claim for Fort William T.S. (Lochaber DC)	0.66	0.66	Anon (1981)

Table 3B.1 Typical densities of bales produced by different balers.

(1) The figures for the bales "at landfill" represent the density of the bale itself, not the effective density of the refuse emplaced at the site.

Appendix 3A, apply regarding the merits and disadvantages of covering.

3B.3 LANDFILL EMPLACEMENT AND SITE VEHICLES

Relatively simple and cheaper site machinery can be used for emplacement of bales. This usually consists of a rubber-tyred vehicle with a fork lift attachment and possibly a dozer or shovel to excavate and spread out the cover. Mobility over the tip surface is also said to be improved (Anon, 1978) with reduction in breakdowns and punctures. Sowerby (1977) points out that both of these reductions have a beneficial effect on vehicle running costs.

3B.4 PESTS AND FIRE RISK

The refuse in the bale is tightly bound. In this physical state any edible material is unpalletable and several authors comment that rodent pests are virtually eliminated (NCRR, 1974; Shepard, 1975). Suggestions that birds and insects are also eradicated are disputed by other workers. Shepard (1979) found "no significant difference in the presence of birds than on a conventional site" and Stone (1975) found no evidence that baling reduces (or increases) insect numbers.

The concentration of free oxygen in bales is low, this it is suggested will reduce the risk of fire. This claim is also disputed. Fires have been reported at a Glasgow site through the baling of burning refuse (Shepard, 1979), and Skitt (1979) suggests that if inter-bale spaces are not kept to the absolute minimum the available air within the refuse mass, may actually increase the fire risk.

3B.5 LITTER

Wind-blown litter is significantly reduced. West Yorkshire CC(1977) claim it is totally eliminated, other writers (Anon, 1979b) are less definitive and use phrases such as "lower incidence".

3B.6 ODOUR

As for pulverised landfills, baled wastes are said to produce no odour. Most landfill operators privately admit some odours arise similar to those reported by the DOE Working Party for pulverised refuse. This may possibly be due to aerobic decomposition proceeding in the inter-bale spaces.

3B.7 RATE OF DECOMPOSITION AND LEACHATES

The decomposition of refuse in bales is open to much speculation. The rate of decomposition within a bale is considered very low and the tightly bound nature will restrict free oxygen and water entering. Consequently, conditions within the bale will probably become anaerobic very quickly. Work by Stone and Kahle (1977) supports this. Since the rate of bale decomposition is low, Skitt (1979) argues leachate will also be lower in concentration. His view, however, is not supported by field observations.

Early experience on sites at Leeds and Glasgow suggests the opposite. Here, particularly strong leachates have been reported. It is speculated that although the bales are decomposing very slowly, air trapped in the inter-bale spaces is promoting rapid aerobic decomposition of the refuse forming the bale faces. It is not known whether this phenomena is only a short term effect to be followed by a later period of low leachate concentration, or whether another mechanism is operating.

3B.8 BULK TRANSPORTER PAYLOADS

Baling has the advantage over other treatments in that once the material has been baled it retains all or most of the increase in density without the subsequent need to compact the refuse into the bulk transporters or recompact the refuse at the landfill when offloaded. It is unlikely, however, that payloads will be greater than those for compaction or pulverisation since both of these methods can also achieve payloads upto the present legal limit.

3B.9 OTHER CONSIDERATIONS

(a) Incompressibles and Breakdowns) The issues raised regarding these
(b) Baler Dust and Noise) points are identical to those discussed for pulverisation (Appendix 3A)

APPENDICES ACCOMPANYING CHAPTER 4

APPENDIX 4A

Detailed Mathematical Description of the Tonneage Estimation Model

Abbreviations used in the following mathematical description

$\bar{x}$ - sample mean

S - sample mean standard deviation

S^2 - sample variance

μ - population mean

σ - population mean standard deviation

σ^2 - population variance

n - sample number of vehicle loads

N - total number of vehicle loads

M, Y and y - Defined in the text

A and B - vehicle capacities

i, ii, iii, iv - Seasons

ν - Degrees of freedom (Greek - nu)

χ^2 - Chi-squared distribution (Greek - chi)

SD - Standard Deviation

CI - Confidence Interval

APPENDIX 4A

4A.1 DETAILED MATHEMATICAL DESCRIPTION OF THE TONNEAGE ESTIMATION MODEL

4A.1.1 Statistical Definitions

The techniques employed in the tonneage estimation model are those commonly used in statistical analyses:

Calculation of means (averages)
Calculation of standard deviations
Derivation of confiidence intervals
Normal, chi-squared and t-distributions
Degrees of freedom

The mean is obtained by summating all measurements and dividing the total by the number of observations.

Where the mean is calculated from only a small proportion of the total number of measurements there will be a difference between this value and that calculated from a second sub-set of the same measurements. The standard deviation (SD) is a measure of this variation. The larger the variation, the less accurate the mean value.

The 95% confidence interval (CI) defines an upper and lower limit on either side of the mean within which it can be expected that 95 in every 100 similar calculations of the mean will lie. The wider the interval, the less reliable the mean value. The 95% CI for the population mean is represented by the sample mean $\pm$ 2 SD.

The normal distribution is a symmetrical, bell-shaped distribution derived when the variations in a set of measurements are unbiased. This is the most common type of distribution curve. Variations in weights of refuse loads are not considered to be biased but arise randomly, it is therefore reasonable to expect these measurements to follow the normal distribution curve.

Degrees of freedom (ν) are used when referring to statistical tables and are calculated by subtracting from the sample size the number of quantities fixed in estimating the variance (e.g. mean value, total frequency). This varies from calculation to calculation.

The number of degrees of freedom for the CI of the SD about the mean value are related to a chi-squared distribution (χ^2). χ^2 tables are used as shown in the following mathematical description to determine the upper and lower limits of the SD CI. The t-distribution is used only when a very small sample has been taken (i.e. $<$ 25).

Each step is detailed mathematically for two vehicle categories; A and B.

4A.2 MATHEMATICAL DESCRIPTION OF THE TONNEAGES ESTIMATION MODEL

Step 1i: Mean Vehicle Payload for each Category

Categories A and B (e.g. vehicle volume capacities). Two categories of vehicle assumed.

mean vehicle payload: A B

$$\frac{\sum_{n_A}^{1} x}{n_A} = \bar{x}_A \qquad \frac{\sum_{n_B}^{1} x}{n_B} = \bar{x}_B$$

Standard deviation : S_{A1} S_{B1}

Where: n_A and n_B are the respective sample sizes,

x are individual sample weightings

Step 1ii: b% confidence intervals (CI) for the population mean payload and Standard Deviation

b% confidence interval: e.g. 95% 95% = 2 x Standard Deviation

mean vehicle payload CI:
($\bar{x}_A$ and $\bar{x}_B$ from above)

A B

$$\bar{x}_A \pm \frac{2 \times \sigma_{A1}}{\sqrt{n_A}} = \mu_{A1} \pm C_{A1} \qquad \bar{x}_B \pm \frac{2 \times \sigma_{B1}}{\sqrt{n_B}} = \mu_{B1} \pm C_{B1}$$

Thus the mean vehicle payloads ($\bar{x}_A$ and $\bar{x}_B$) become the population mean vehicle payloads (μ_{A1} and μ_{B1})

Standard deviation CI: Assume tonneages are normally distributed about the capacity of the vehicle using:

$$\nu = \frac{(n-1)s^2}{\sigma^2}$$

The theoretical distribution of the values of ν correspond to the χ^2 distribution and by identifying this one can use it to establish any desired confidence interval (b). The bounds of the 95% confidence interval are given by:

$$\chi_1^2 > \nu > \chi_2^2$$

where: χ_1^2 is the 97.5% S.L. at (n-1)°F $\chi_1^2 = \frac{1}{2}\left(-Z + \sqrt{2x(n-1)-1}\right)^2$

χ_2^2 is the 2.5% S.L. at (n-1)°F $\chi_2^2 = \frac{1}{2}\left(Z + \sqrt{2x(n-1)-1}\right)^2$

Z and -Z taken from χ^2 tables representing 2.5% and 97.5% significance levels respectively

$$\chi_1^2 > \frac{(n-1)s^2}{\sigma^2} > \chi_2^2$$

$$\frac{(n-1)s^2}{\chi_1^2} > \sigma^2 > \frac{(n-1)s^2}{\chi_2^2}$$

$$\sqrt{\frac{(n-1)s^2}{\chi_1^2}} > \sigma > \sqrt{\frac{(n-1)s^2}{\chi_2^2}}$$

N.B. One should consider using a t-distribution for this calculation where sample sizes are small (approximately $\leqslant 20$).

Therefore, the b% confidence interval about the standard deviation of the mean vehicle payload is:

A

$$\sqrt{\frac{(n_A-1)S_{A1}^2}{\chi_1^2}} > \sigma_{A1} > \sqrt{\frac{(n_A-1)S_{A1}^2}{\chi_2^2}}$$

B

$$\sqrt{\frac{(n_B-1)S_{B1}^2}{\chi_1^2}} > \sigma_{B1} > \sqrt{\frac{(n_{B-1})S_{B1}^2}{\chi_2^2}}$$

Step 1iii: Percentage of vehicles weighed relative to the total number of disposal trips in the sampling period

Sampling period: e.g. seasons or other annually occurring cyclical fluctuations in arisings

Sampling period percentage: $\frac{n_A + n_B}{N_A + N_B} \times 100 = y\%$

where: N_A and N_B are the respective total number of disposal trips in the sampling period.

Step 2: Sampling period total tonneage for each category

Sampling period total tonneage: (μ_{A2} and μ_{B2})

$$\underline{A} \qquad \mu_{A1} \times N_A = \mu_{A2} \qquad\qquad \underline{B} \qquad \mu_{B1} \times N_B = \mu_{B2}$$

Standard deviation: (σ_{A2} and σ_{B2})

$$\sqrt{\sigma^2_{A1} \times N_A} = \sigma_{A2} \qquad \sqrt{\sigma^2_{B1} \times N_B} = \sigma_{B2}$$

The procedure outlined in the steps 1i, 1ii, 1iii and 2 should be repeated for each distinct period or season occuring within the year. The sampling period total tonneage for each category of vehicle can then be aggregated into a "Seasonal total tonneage" by multiplying by the number of sampling period time intervals (m) in the season being calculated. This is repeated for each season using the respective sampling period total tonneages and intervals. In this example four seasons are assumed all of equal length, i.e.

M = No. of weeks in a season ÷ No. of weeks in sampling period

Step 3: Seasonal total tonneage for each category

	A	B
Season i total tonneage: (μ_{A3i} and μ_{B3i})	$\mu_{A2i} \times M = \mu_{A3i}$	$\mu_{B2i} \times M = \mu_{B3i}$
Standard deviation: (σ_{A3i} and σ_{B3i})	$\sqrt{\sigma^2_{A2i} \times M} = \sigma_{A3i}$	$\sqrt{\sigma^2_{B2i} \times M} = \sigma_{B3i}$
Season ii total tonneage: (μ_{A3i} and μ_{B3i})	$\mu_{A2ii} \times M = \mu_{A3ii}$	$\mu_{B2ii} \times M = \mu_{B3ii}$
Standard deviation: (σ_{A3ii} and σ_{B3ii})	$\sqrt{\sigma^2_{A2ii} \times M} = \sigma_{A3ii}$	$\sqrt{\sigma^2_{B2ii} \times M} = \sigma_{B3ii}$
Season iii total tonneage: (μ_{A3iii} and μ_{B3iii})	$\mu_{A2iii} \times M = \mu_{A3iii}$	$\mu_{B2iii} \times M = \mu_{B3iii}$
Standard deviation: (σ_{A3iii} and σ_{B3iii})	$\sqrt{\sigma^2_{A2iii} \times M} = \sigma_{A3iii}$	$\sqrt{\sigma^2_{B2iii} \times M} = \sigma_{B3iii}$
Season iv total tonneage: (μ_{A3iv} and μ_{B3iv})	$\mu_{A2iv} \times M = \mu_{A3iv}$	$\mu_{B2iv} \times M = \mu_{B3iv}$
Standard deviation: (σ_{A3iv} and σ_{B3iv})	$\sqrt{\sigma^2_{A2iv} \times M} = \sigma_{A3iv}$	$\sqrt{\sigma^2_{B2iv} \times M} = \sigma_{B3iv}$

Step 4: Annual total tonneage for each category

A B

Annual total tonneage:
(μ_{AZ} and μ_{BZ}

$$\sum_{x=iv}^{i} \mu_{A3x} = \mu_{AZ} \qquad \sum_{x=iv}^{i} \mu_{B3x} = \mu_{BZ}$$

Standard deviation:
($_{AZ}$ and $_{BZ}$

$$\sqrt{\sum_{x=iv}^{i} \sigma^2_{A3x}} = \sigma_{AZ} \qquad \sqrt{\sum_{x=iv}^{i} \sigma^2_{B3x}} = \sigma_{BZ}$$

Step 5i: Grand annual total tonneage for all categories

Grand annual total tonneage:
(μ_{TZ})

$$\mu_{AZ} + \mu_{BZ} = \mu_{TZ}$$

Standard deviation:
(σ_{TZ})

$$\sqrt{\left(\sigma^2_{AZ} + \sigma^2_{BZ}\right)} = \sigma_{TZ}$$

Step 5ii: b% confidence interval for the grand annual total tonneage for all categories

b% confidence interval: e.g. 95% 95% = 2 x Standard Deviation

Grand annual total tonneage: $\mu_{TZ} \pm 2 \times \sigma_{TZ} = \mu_{TZ} \pm C_{TZ}$

Step 5iii: Percentage of vehicles weighed relative to the total number of disposal trips in the year

Annual percentage:

$$\frac{(n_{Ai} + n_{Bi}) + (n_{Aii} + n_{Bii}) + (n_{Aiii} + n_{Biii}) + (n_{Aiv} + n_{Biv})}{[(N_{Ai} + N_{Bi}) + (N_{Aii} + N_{Bii}) + (N_{Aiii} + N_{Biii}) + (N_{Aiv} + N_{Biv})]} \times 100 = Y\%$$

APPENDIX 4B

Simulated Vehicle Weights for 2% of the annual number of loads

SPRING

	Capacity (yd³)	Vehicle Categories 15 (tonnes)	Vehicle Categories 20 (tonnes)	Weekly Total Number of Loads 15	Weekly Total Number of Loads 20
Week 1	Site 1 - Monday	5·2	7·5		
		4·9	6·1		
		5·5	6·2		
		5·8	7·7		
		4·5	7·0		
		5·0	7·1		
		4·5	6·5		
		6·0	6·5		
		5·7	7·5		
		4·8	6·3		
		5·0	6·9		
		5·2	7·2		
		5·5	7·9		
			6·1		
			6·2	61	72
	Site 2 No weighings undertaken in Week 1			54	38
	Site 3 - Thursday	4·5			
		4·2			
		4·8			
		5·0			
		4·2			
		4·4		30	0
Week 2	Site 1 - Monday	5·4	7·0		
		5·1	7·0		
		4·4	6·1		
		5·2	6·8		
		5·0	7·7		
		4·9	7·9		
		4·6	6·5		
		4·5	7·9		
		5·0	6·4		
		5·1	6·8		
		4·4	7·0		
		4·6	7·1		
		4·9	7·8		
		5·3	7·1		
			6·3	64	73
	Site 2 - Wednesday	5·5	7·0		
		4·7	7·9		
		4·9	6·5		
		5·8	6·3		
		5·0	6·9		
		4·2	7·8		
		4·3	7·2		
		5·1	7·9		
		5·8	6·1		
		4·2		54	45
	Site 3 No weighings undertaken in Week 2				
	Sample means	4·9	6·9		
	Standard deviation	0.4	0·6		
	Sample size	43	39		

Total Number of Loads in Sampling Period

292 228

SUMMER

		Vehicle Categories		Weekly Total Number of Loads	
	Capacity (yd^3)	15	20	15	20
		(tonnes)			
Week 1	Site 1 No weighings undertaken in Week 1			63	74
	Site 2 - Monday	5·3	7·4		
		5·2	6·8		
		4·8	6·6		
		4·3	6·0		
		3·8	6·4		
		4·0	6·5		
		4·5	6·8		
		5·0	5·9		
		4·8			
		4·2		53	44
	Site 3 - Wednesday	4·9			
		4·6			
		4·4			
		3·8			
		4·0			
		3·8		30	0
Week 2	Site 1 - Friday	5·3	6·5		
		5·4	7·3		
		4·5	7·4		
		4·6	6·0		
		3·6	6·4		
		4·8	5·8		
		4·9	6·5		
		3·8	7·3		
		4·4	7·0		
		4·8	5·8		
		4·6	6·4		
		4·2	6·4		
		3·9	7·3		
			6·6	65	70
	Site 2 No weighings undertaken in Week 2			55	39
	Site 3 - Tuesday	5·0			
		5·3			
		5·5			
		3·8			
		4·3			
		4·7			
		3·6		30	0
				Total Number of Loads in Sampling Period	
	Sample means	4·5	6·6		
	Standard deviation	0·5	0·5		
	Sample size	36	22	296	227

AUTUMN

	Capacity (yd^3)	Vehicle Categories		Weekly Total Number of Loads	
		15	20	15	20
		(tonnes)			
Week 1	Site 1 - Wednesday	5·3	7·3		
		5·4	7·5		
		5·8	7·8		
		4·5	6·5		
		4·8	6·3		
		5·2	7·0		
		5·1	7·5		
		4·7	6·5		
		4·5	6·7		
		4·9	5·4		
		4·8	7·3		
		5·3	7·5		
			6·1	64	68
	Site 2 - Monday	4·9	7·4		
		5·3	7·8		
		6·0	7·1		
		4·7	6·5		
		4·8	6·9		
		5·0	7·4		
		5·7	6·3		
		5·5	7·1		
		4·8			
		4·3			
		5·1		57	35
	Site 3 No weighings undertaken in Week 1			32	0
Week 2	Site 1 No weighings undertaken in Week 2			64	68
	Site 2 - Tuesday	5·0	7·0		
		5·1	6·2		
		5·8	7·3		
		4·9	7·5		
		6·0	6·5		
		4·7	6·4		
		5·1	7·1		
		4·6	7·8		
		4·9			
		5·5			
		4·2		54	38
	Site 3 - Thursday	5·1			
		5·3			
		4·2			
		4·8			
		5·5			
		5·1			
		4·3		32	0
	Sample means	5·0	7·0	Total Number of Loads in Sampling Period	
	Standard deviation	0·4	0·6		
	Sample size	41	29	303	209

WINTER		Vehicle Categories (tonnes)		Weekly Total Number of Loads	
	Capacity	15	20	15	20
Week 1	Site 1 - Thursday	6.0	6.7		
		5.1	7.0		
		6.3	7.8		
		4.6	7.4		
		6.4	8.0		
		5.5	7.7		
		5.2	8.4		
		5.4	7.6		
		5.7	8.3		
		4.9	7.0		
		5.8	7.0		
		5.6	7.5		
			7.8		
			8.3		
			6.8	63	74
	Site 2 - Monday	6.4	7.8		
		5.8	7.5		
		5.4	7.6		
		6.3	7.3		
		6.1	7.4		
		5.2	8.0		
		5.3	8.3		
		5.5	7.0		
		5.4			
		6.3		55	39
	Site 3 No weighings undertaken in Week 1			30	0
Week 2	Site 1 - Wednesday	5.5	7.4		
		4.8	7.3		
		6.5	6.8		
		6.6	6.9		
		5.3	8.0		
		4.8	7.4		
		5.2	7.5		
		6.1	8.2		
		5.7	8.1		
		5.3	7.5		
		5.9	7.3		
		6.4	7.0		
			6.5		
			7.1	64	73
	Site 2 No weighings undertaken in Week 2			55	39
	Site 3 - Friday	5.3			
		5.4			
		5.5			
		4.8			
		5.9			
		5.7			
		6.8		29	0
				Total Number of Loads in Sampling Period	
	Sample means	5.6	7.4		
	Standard deviation	0.5	0.5		
	Sample size	41	37	296	225

Additional simulated vehicle loads
(These extra values together with those on preceeding pages total 4%
of the annual number of loads.)

Vehicle capacity (yd^3)	15				20			
Season	Sp	Su	A	W (tonnes)	Sp	Su	A	W
	5•4	5•4	4•2	5•0	7•9	5•7	6•2	6•9
	4•3	5•0	5•8	5•6	8•0	6•4	7•9	7•7
	4•9	4•7	5•5	6•1	6•3	6•9	6•8	8•2
	5•4	4•9	4•3	6•3	6•1	6•9	6•7	7•2
	5•2	3•9	4•7	4•8	7•2	6•8	7•4	6•9
	5•9	4•1	5•9	4•7	7•3	7•4	6•8	8•0
	4•1	4•4	5•2	6•4	7•4	6•2	7•8	8•4
	4•3	4•7	5•0	4•8	6•1	6•8	7•3	7•5
	4•7	4•0	4•3	6•2	6•8	6•8	7•2	7•9
	4•7	3•9	5•1	6•4	6•4	6•9	6•8	7•3
	5•0	4•9	5•5	5•6	6•9	6•9	7•3	6•8
	5•3	4•5	4•7	4•4	7•1	7•1	6•4	6•7
	5•8	5•5	4•3	5•3	6•5	7•1	6•7	6•6
	5•4	3•5	4•5	5•7	7•3	6•6	7•1	8•3
	5•4	4•6	5•2	6•4	7•2	6•0	7•3	7•8
	4•7	4•3	5•1	5•0	7•1	7•8	7•0	7•7
	5•2	4•7	5•1	6•1	7•7	7•2	7•3	7•4
	4•1	4•8	4•8	4•8	7•9	6•1	7•2	7•1
	6•0	5•2	5•3	5•7	7•8		6•5	7•0
	5•7	3•6	4•2	6•0	6•5		7•7	8•1
	5•4	3•8	4•1	5•4	6•9		7•4	7•8
	5•3	4•6	5•7	6•3	7•0		6•3	8•3
	5•0	4•7	5•1	6•2	6•5		6•6	6•8
	4•7	4•4	5•0	4•8	7•2		7•2	6•9
	4•8	4•3	6•0	5•4	7•3		7•9	6•6
	4•9	4•2	4•7	5•8	6•1			6•6
	5•0	5•0	4•9	5•1	7•8			7•3
	4•3	4•7	4•0	6•4	7•9			7•9
	5•1	3•0	4•1	4•1	6•7			7•8
	5•2	5•0	5•1	4•8	6•8			7•4
	4•0	5•3	5•3	5•5	7•1			8•0
	5•3	4•9	5•2	5•2	7•0			7•5
	4•8		5•8	4•8	8•0			8•2
	4•7		5•3	6•3	5•9			
	4•8		4•5	5•6	6•3			
	5•1		5•1	6•2	6•3			
	5•9		5•1	5•0				
	5•6							
	5•3							

APPENDIX 4C

Evaluation of the Tonneage Estimation Model Using Simulated Data: A Worked Example

APPENDIX 4C

EVALUATION OF THE TONNEAGE ESTIMATION MODEL USING SIMULATED DATA

A Worked Example

(values in steps 1, 2 and 3 for season i only) (tonnes)

Step 1i: Mean vehicle payload for each category

Vehicle Capacities (yd^3)	15	20
mean vehicle payload:	4.9	6.9
SD	0.4	0.6
where sample sizes are:	n = 43	n = 39

Step 1ii: 95% confidence intervals for the population mean vehicle payload and standard deviation

mean vehicle payload CI:

$$4.9 \pm \frac{2 \times 0.4}{\sqrt{43}} \qquad 6.9 \pm \frac{2 \times 0.6}{\sqrt{39}}$$

$$4.9 \pm 0.1 \qquad 6.9 \pm 0.2$$

SD CI : SD = 0.4 SD = 0.6

Using the χ^2 distribution:

97.5% S.L. -

$$\chi_1^2 = \tfrac{1}{2}(-1.96 + \sqrt{2 \times 42-1})^2 \qquad \chi_1^2 = \tfrac{1}{2}(-1.96 + \sqrt{2 \times 38-1})^2$$

$$\chi_1^2 = 25.17 \qquad \chi_1^2 = 22.06$$

2.5% S.L. -

$$\chi_1^2 = \tfrac{1}{2}(1.96 + \sqrt{2 \times 42-1})^2 \qquad \chi_1^2 = \tfrac{1}{2}(1.96 + \sqrt{2 \times 38-1})^2$$

$$\chi_1^2 = 60.67 \qquad \chi_1^2 = 55.78$$

$$\sqrt{\frac{(43-1)0.49^2}{25.17}} > \sigma > \sqrt{\frac{(43-1)0.49^2}{60.67}} \qquad \sqrt{\frac{(39-1)0.61^2}{22.06}} > \sigma > \sqrt{\frac{(39-1)0.61^2}{55.78}}$$

$$0.63 > \sigma > 0.41 \qquad 0.80 > \sigma > 0.50$$

Interval width 0.22
Approx 45% of SD

Interval width 0.30
Approx 49% of SD

Step 1iii: Percentage of vehicles weighed relative to the total number of disposal trips in the sampling period

(sampling period = 2 weeks)

	15	20
Total no. of disposal trips made in sampling period:	292	228

Sampling period percentage:

$$\frac{43 + 39}{292 + 228} \text{ X } 100$$

$$= 15.8\%$$

Step 2: Sampling period total tonneage for each category

Sampling period total tonneage:	4.9 x 292	6.9 x 228
	1442	1589
SD:	$\sqrt{0.4^2 \text{ x } 292}$	$\sqrt{0.6^2 \text{ x } 228}$
	8.4	9.2

Step 3: Seasonal total tonneages for each category

No. of weeks in season i: 13

M: No. of weeks in season ÷ No. of weeks in sampling period: $\frac{13}{2} = 6.5$

Season i total tonneage:	1442 x 6.5	1589 x 6.5
	9373	10329
SD:	$\sqrt{8.4^2 \text{ x } 6.5}$	$\sqrt{9.2^2 \text{ x } 6.5}$
	21.4	23.5

Season ii total tonneage	8678	9737
and SD	24.2	19.9
Season iii total tonneage	9926	9510
and SD	20.4	22.2
Season iv total tonneage	10868	10953
and SD	24.2	19.6

Step 4: Annual total tonneage for each category

	12	20
Annual total tonneage:	9373+8678+9926+10868	10329+9737+9510+10953
	38845	40529
SD:	$\sqrt{21.4^2+24.2^2+20.4^2+24.2^2}$	$\sqrt{23.5^2+19.9^2+22.2^2+19.6^2}$
	45.2	42.7

Step 5i: Grand annual total tonneage for all categories

Grand annual total tonneage: 38845 + 40529

79374

SD: $\sqrt{45.2^2 + 42.7^2}$

62.2

Step 5ii: 95% confidence interval for the grand annual total tonneage for all categories

Grand annual total tonneage: $79374 \pm 2 \times 62.2$

79374 ± 124

Step 5iii: Percentage of vehicle weighed relative to the total number of disposal trips in the year

Annual percentage: $$\frac{43+39+36+22+41+29+41+37}{(292+228+296+227+303+209+296+225)6.5} \text{ X } 100$$

2.1%

The results of this worked example are summarised in Table 4.5.

APPENDICES ACCOMPANYING CHAPTER 5

APPENDIX 5A

Results of the Linear Regression Analyses and t-tests on each Disposal Method between 1974/5 and 1980/1

Year 1974/5

Disposal Method		Mean Cost/ tonne (£/t)	S.D. of mean cost/ tonne (£/t)	t	Coefficient of Determination R^2	No. of Observations	Comments on R^2
Direct Landfill	Incl. GLC	1.07	0.65	1.65	0.68	41	R^2 dominated by GLC
	Excl. GLC	1.00	0.47	2.13*	0.46	40	R^2 low
Pulverisation and landfill	Incl. GLC	3.27	1.54	2.12*	0.85	26	R^2 high not influenced by GLC
	Excl. GLC	3.21	1.54	2.08*	0.85	25	
Direct Incineration and Landfill	Incl. GLC	7.36	3.90	1.89*	0.93	17	R^2 high not influenced by GLC
	Excl. GLC	7.39	4.02	1.84*	0.89	16	

* t statistic: mean cost/tonne significantly different from zero at 5% SL

Year 1975/6

Disposal Method		Mean Cost/ tonne (£/t)	S.D. of mean cost/ tonne (£/t)	t	Coefficient of Determination R^2	No. of Observations	Comments on R^2
Direct Landfill	Incl. GLC	1.47	0.84	1.75*	0.74	44	
	Excl. GLC	1.39	0.63	2.21*	0.56	43	Moderate R^2
Pulverisation and landfill	Incl. GLC	-	-	-	-	-	No GLC figures for this method
	Excl. GLC	5.11	3.15	1.62	0.73	28	High R^2
Direct Incineration and Landfill	Incl. GLC	9.30	3.58	2.60**	0.97	21	High R^2 not affected by GLC
	Excl. GLC	9.23	3.66	2.52*	0.96	20	

* t statistic: mean cost/tonne significantly different from zero at 5% SL

** t statistic: mean cost/tonne significantly different from zero at 1% SL

Year 1976/7

Disposal Method		Mean Cost/ tonne (£/ t)	S.D. of mean cost/ tonne (£/'t)	t	Coefficient of Determination R^2	No. of Observations	Comments on R^2
Direct Landfill	Incl. GLC	1.72	1.04	1.65	0.67	45	
	Excl. GLC	1.60	0.73	2.19*	0.56	44	Moderate R^2
Pulverisation and landfill	Incl. GLC	5.17	2.44	2.12*	0.51	28	Moderate R^2 GLC dominates figures
	Excl. GLC	5.30	2.39	2.22*	0.92	27	High R^2
Direct Incineration and Landfill	Incl. GLC	9.91	3.98	2.49*	0.90	22	High R^2 not influenced by GLC
	Excl. GLC	9.90	4.08	2.43*	0.85	21	

* t statistic: mean cost/tonne significantly different from zero at 5% SL

Year 1977/8

Disposal Method		Mean Cost/ tonne (£/t)	S.D. of mean cost/ tonne (£/t)	t	Coefficient of Determination R^2	No. of Observations	Comments on R^2
Direct Landfill	Incl. GLC	2.12	1.09	1.94*	0.71	43	Some influence from GLC figures
	Excl. GLC	2.01	0.81	2.48**	0.63	42	Moderate R^2
Pulverisation and landfill	Incl. GLC	5.99	2.30	2.60**	0.96	21	High R^2 not influenced by GLC
	Excl. GLC	5.81	2.19	2.65**	0.95	20	
Direct Incineration and Landfill	Incl. GLC	11.20	4.09	2.74**	0.91	21	High R^2 not influenced by GLC
	Excl. GLC	11.28	4.18	2.70**	0.87	20	

* t statistic: mean cost/tonne significantly different from zero at 5% SL

** t statistic: mean cost/tonne significantly different from zero at 1% SL

Year 1978/9

Disposal Method		Mean Cost/ tonne (£/t)	S.D. of mean cost/ tonne (£/t)	t	Coefficient of Determination R^2	No. of Observations	Comments on R^2
Direct Landfill	Incl. GLC	2.50	1.27	1.97*	0.63	46	Moderate R^2 not influenced by GLC
	Excl. GLC	2.39	1.03	2.32*	0.62	45	
Pulverisation and landfill	Incl. GLC	7.82	2.97	2.63**	0.92	24	High R^2 not influenced by GLC
	Excl. GLC	7.57	2.94	2.57**	0.86	23	
Direct Incineration and Landfill	Incl. GLC	11.83	5.05	2.34*	0.81	22	High R^2 not influenced by GLC
	Excl. GLC	11.75	5.16	2.28*	0.78	21	

* t statistic: mean cost/tonne significantly different from zero at 5% SL

** t statistic: mean cost/tonne significantly different from zero at 1% SL

Year 1979/80

Disposal Method		Mean Cost/ tonne (£/ t)	S.D. of mean cost/ tonne (£/ t)	t	Coefficient of Determination R^2	No. of Observations	Comments on R^2
Direct Landfill	Incl. GLC	3.19	1.75	1.82*	0.67	46	Moderate R^2 value influenced by GLC
	Excl. GLC	3.05	1.50	2.03*	0.40	45	
Pulverisation and landfill	Incl. GLC	12.31	6.98	1.76*	0.83	20	Moderate R^2 influenced by GLC
	Excl. GLC	12.26	7.17	1.71	0.68	19	
Direct Incineration and Landfill	Incl. GLC	15.90	7.24	2.20*	0.91	23	High R^2 not influenced by GLC
	Excl. GLC	16.01	7.39	2.17*	0.90	22	

* t statistic: mean cost/tonne significantly different from zero at 5% SL

Year 1980/1

Disposal Method		Mean Cost/ tonne (£/t)	S.D. of mean cost/ tonne (£/t)	t	Coefficient of Determination R^2	No. of Observations	Comments on R^2
Direct Landfill	Incl. GLC	3.30	2.17	1.52	0.72	45	R^2 value seriously influenced by GLC
	Excl. GLC	3.14	1.88	1.67*	0.38	44	
Pulverisation and landfill	Incl. GLC	9.90	4.41	2.24*	0.83	15	High R^2 not influenced by GLC
	Excl. GLC	9.45	4.20	2.25*	0.89	14	
Direct Incineration and Landfill	Incl. GLC	11.01	4.23	2.60**	0.90	21	High R^2 not influenced by GLC
	Excl. GLC	11.13	4.30	2.59**	0.92	20	

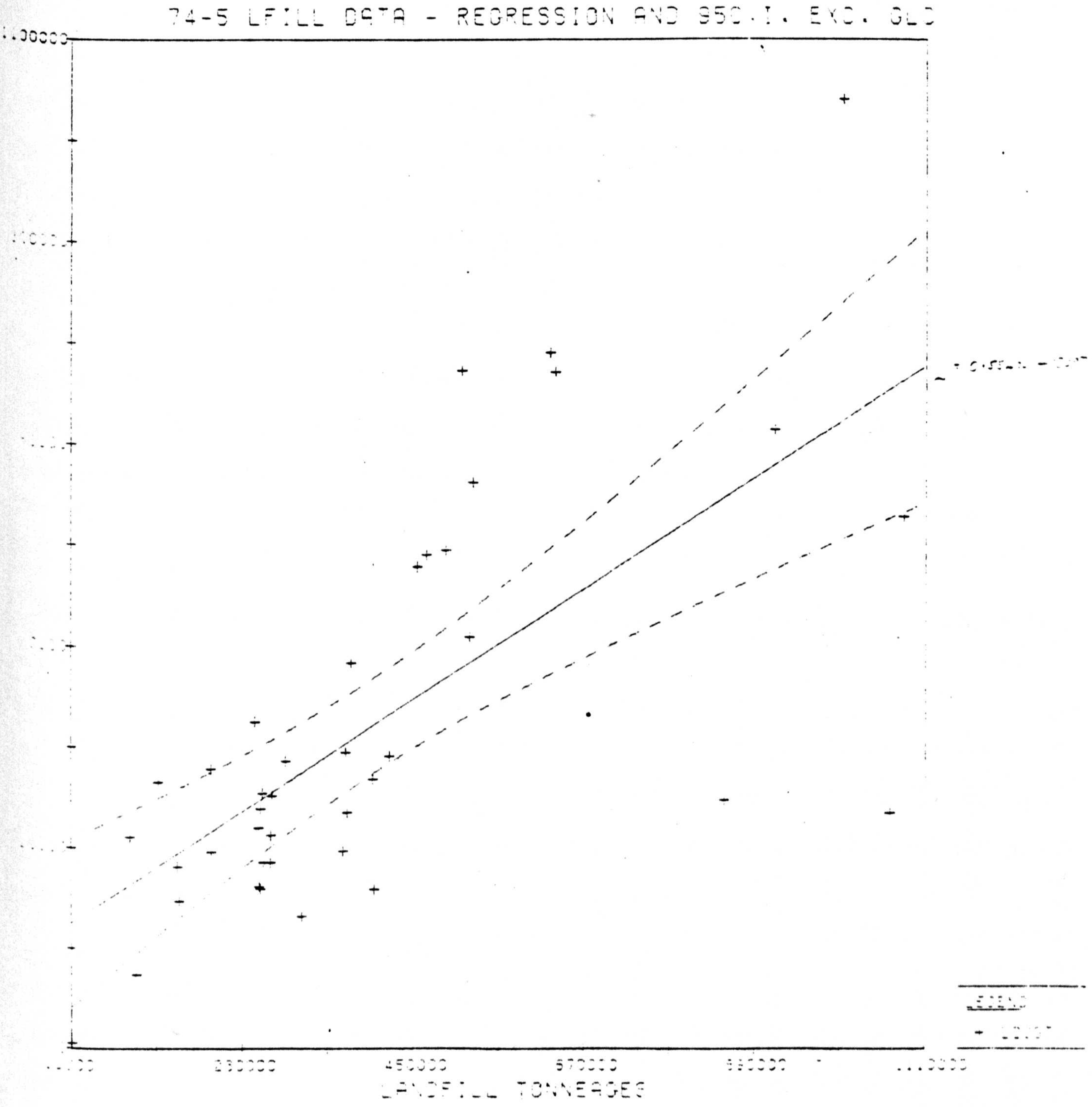
* t statistic: mean cost/tonne significantly different from zero at 5% SL

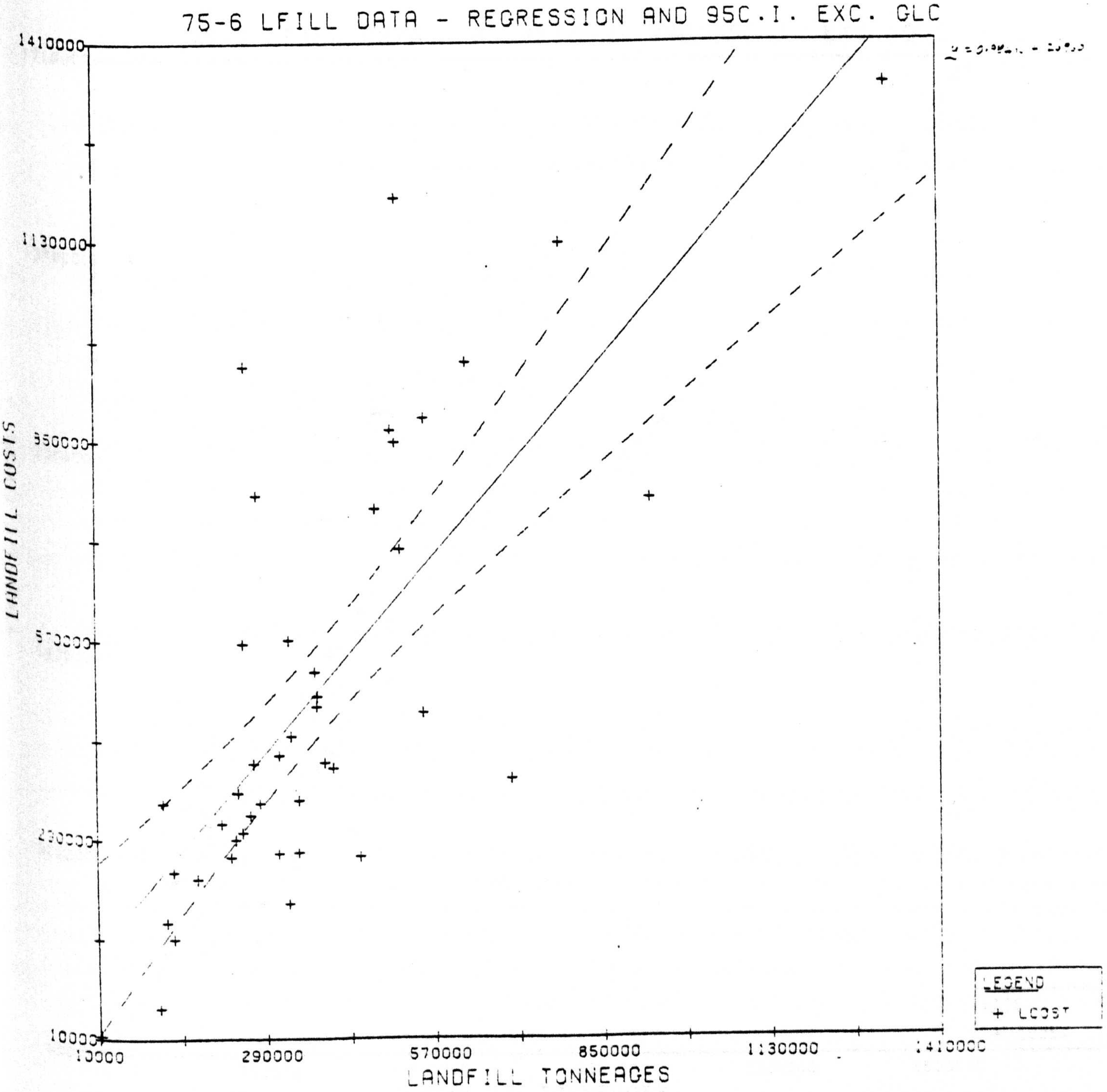
** t statistic: mean cost/tonne significantly different from zero at 1% SL

APPENDIX 5B

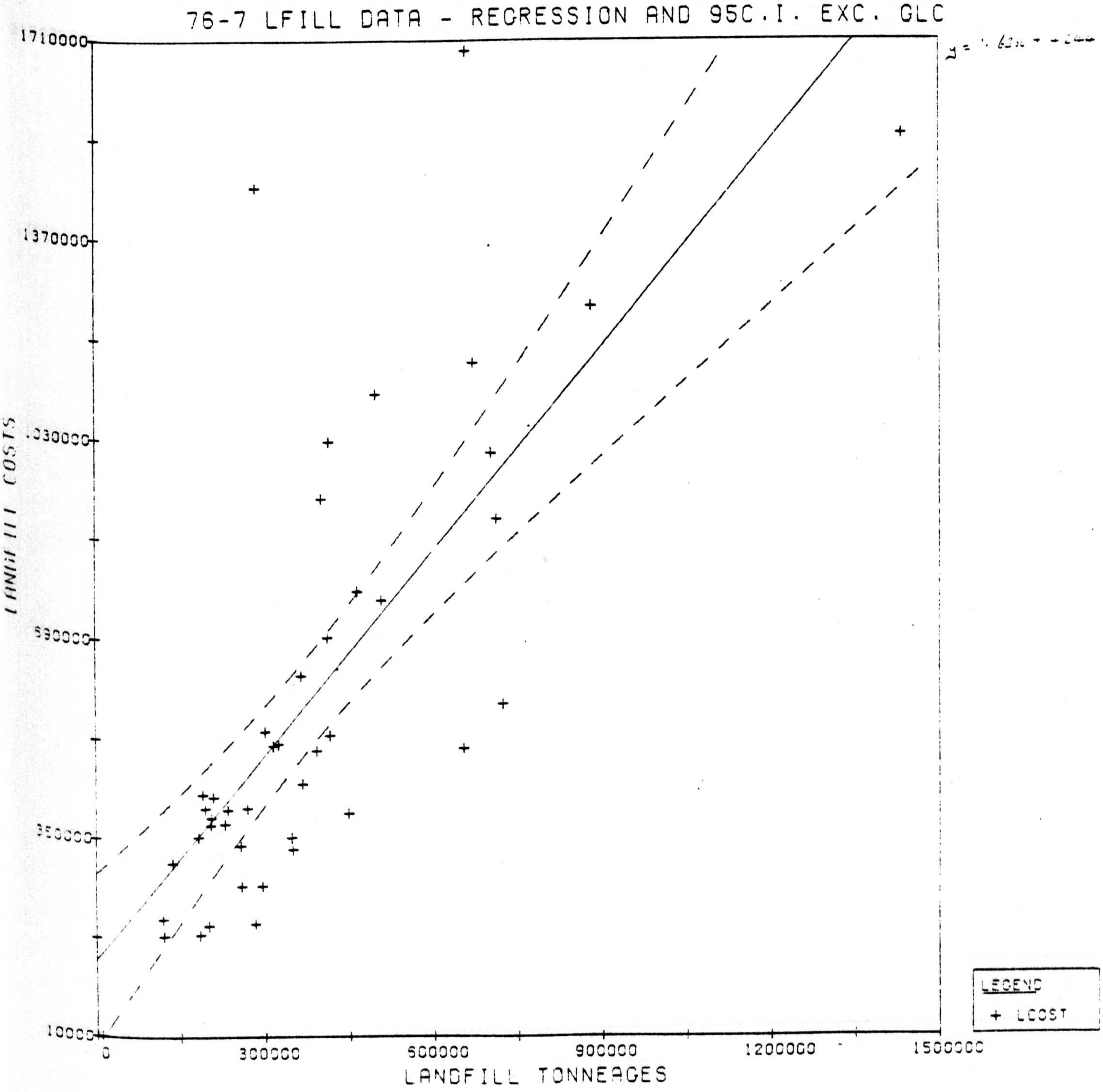
Computer Plots of Selected Regression Curves

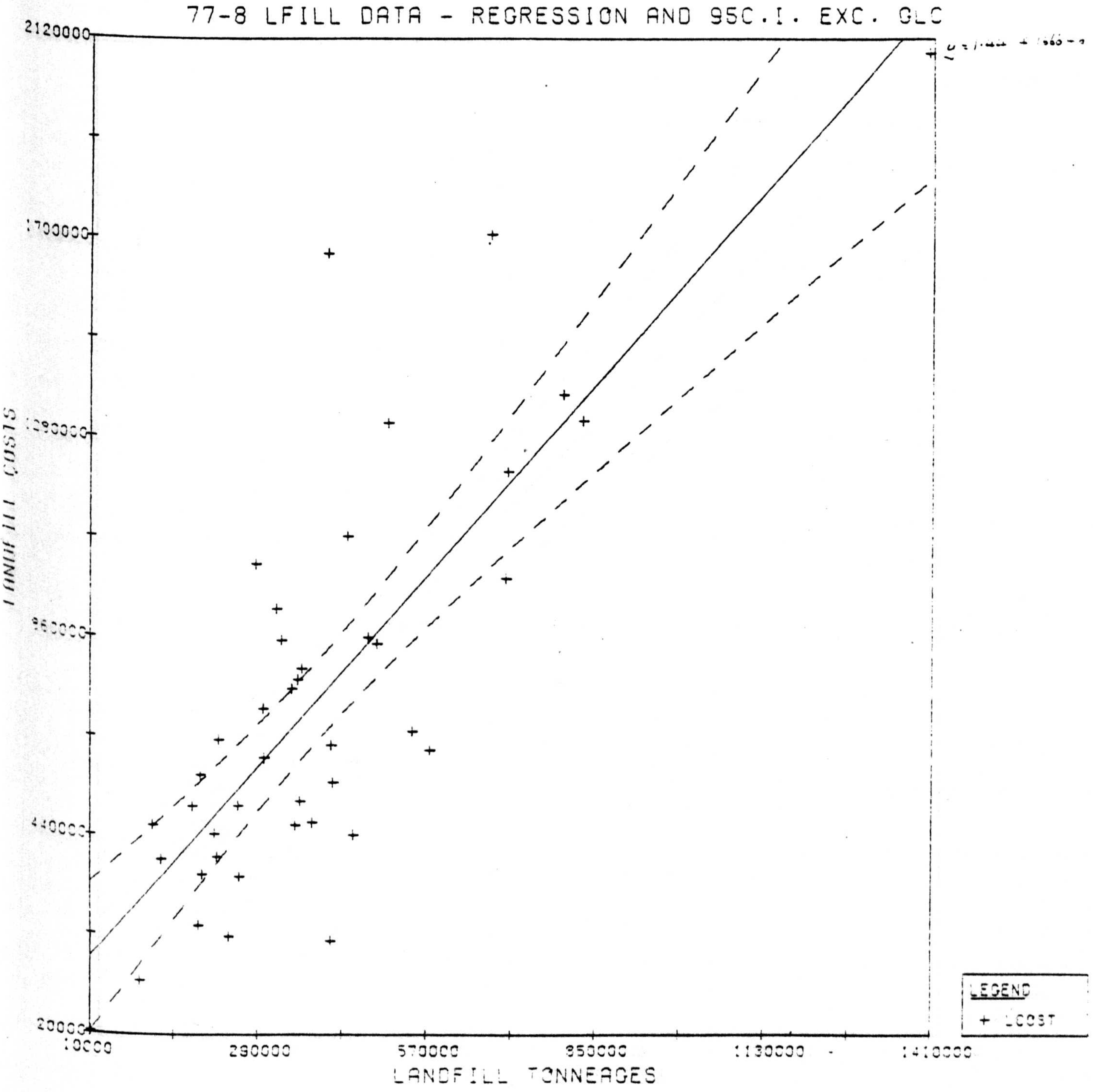
Regression curves for the landfill disposal method between the years 1974/5 and 1980/1 are presented in this apprendix. Similar curves were also produced during this research for the pulverisation and incineration disposal methods, though they are not included here.

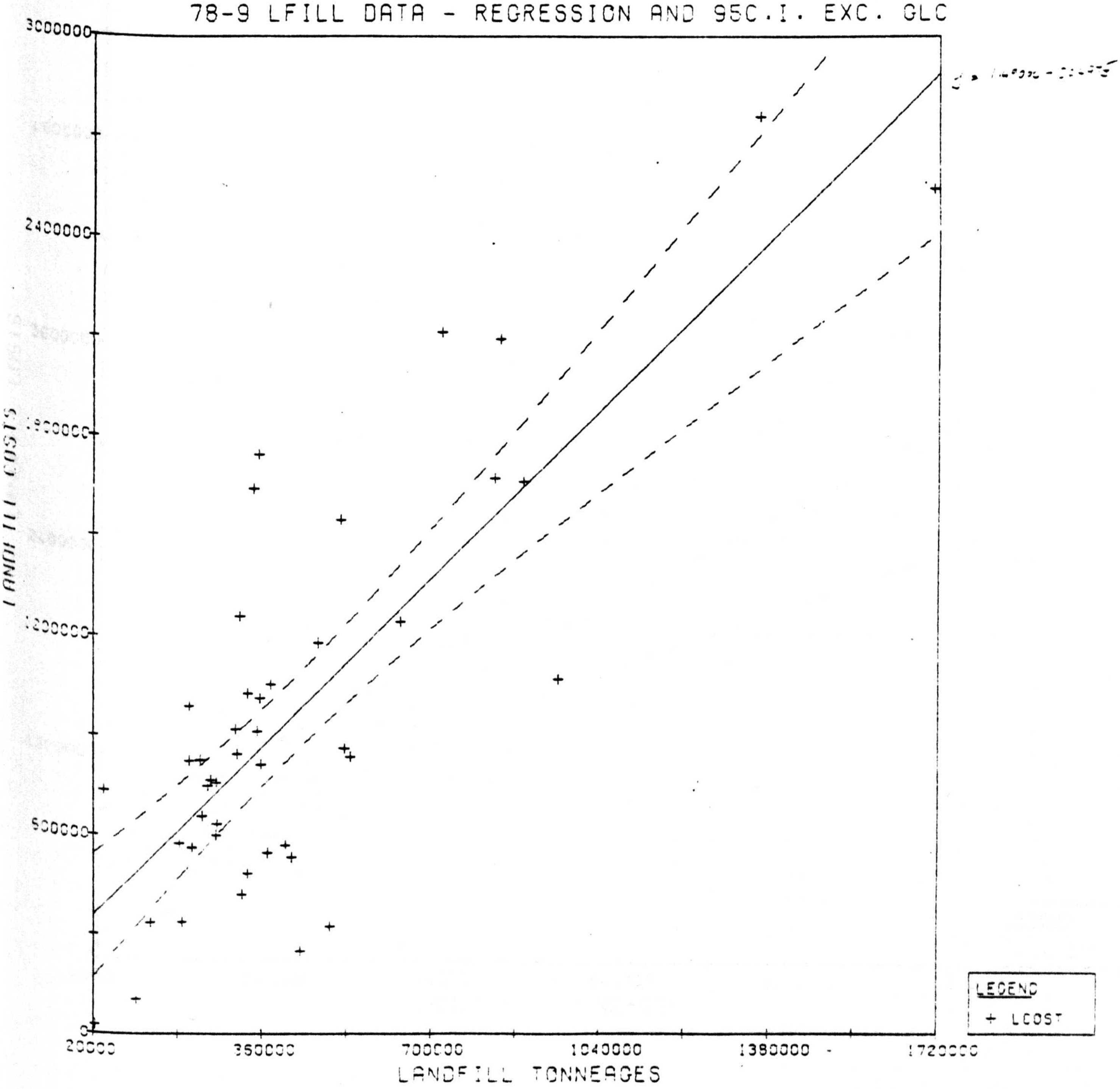

74-5 LFILL DATA - REGRESSION AND 95C.I. EXC. OLD
230000
450000
670000
890000
LANDFILL TONNEAGES
LEGEND

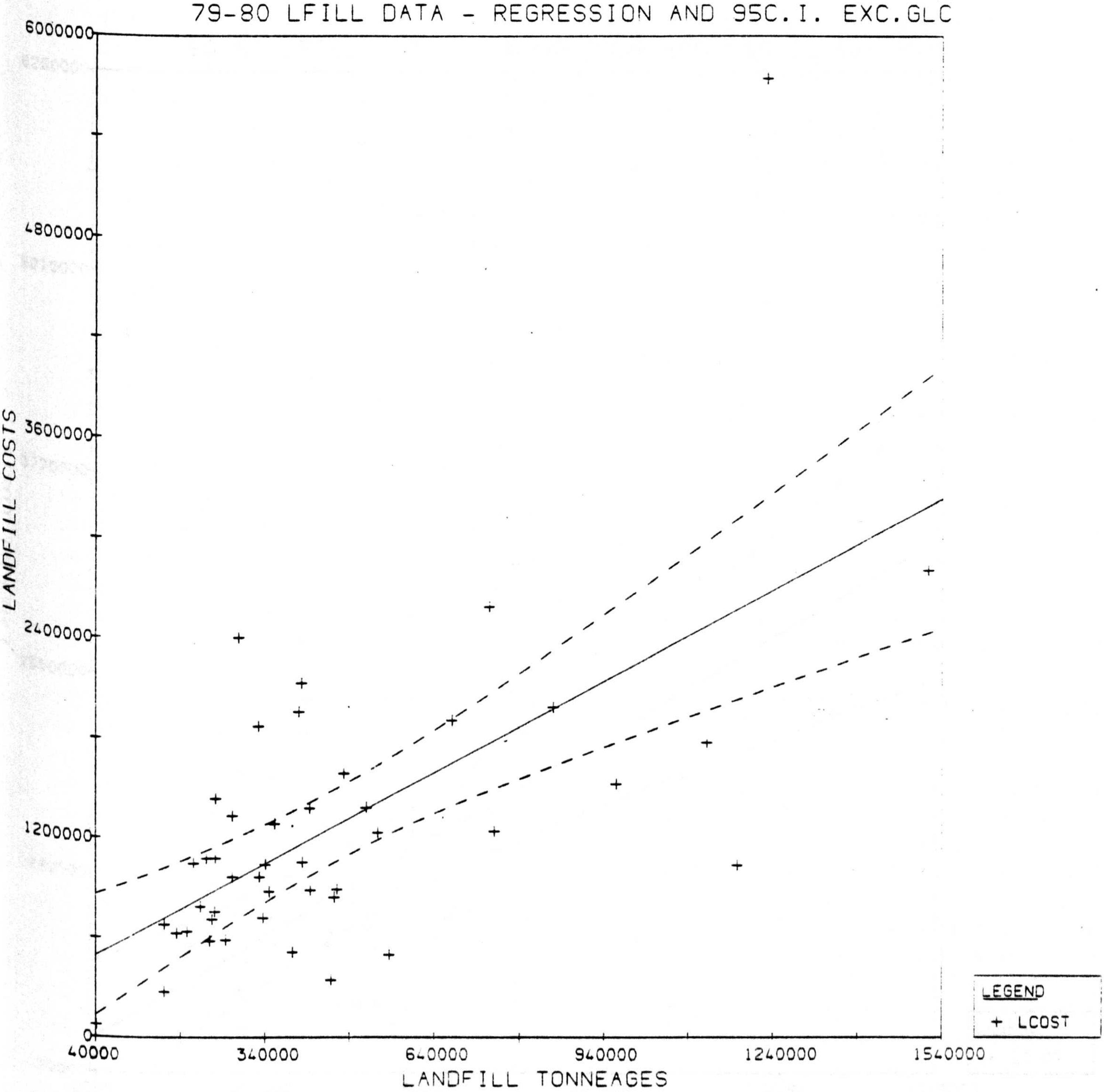


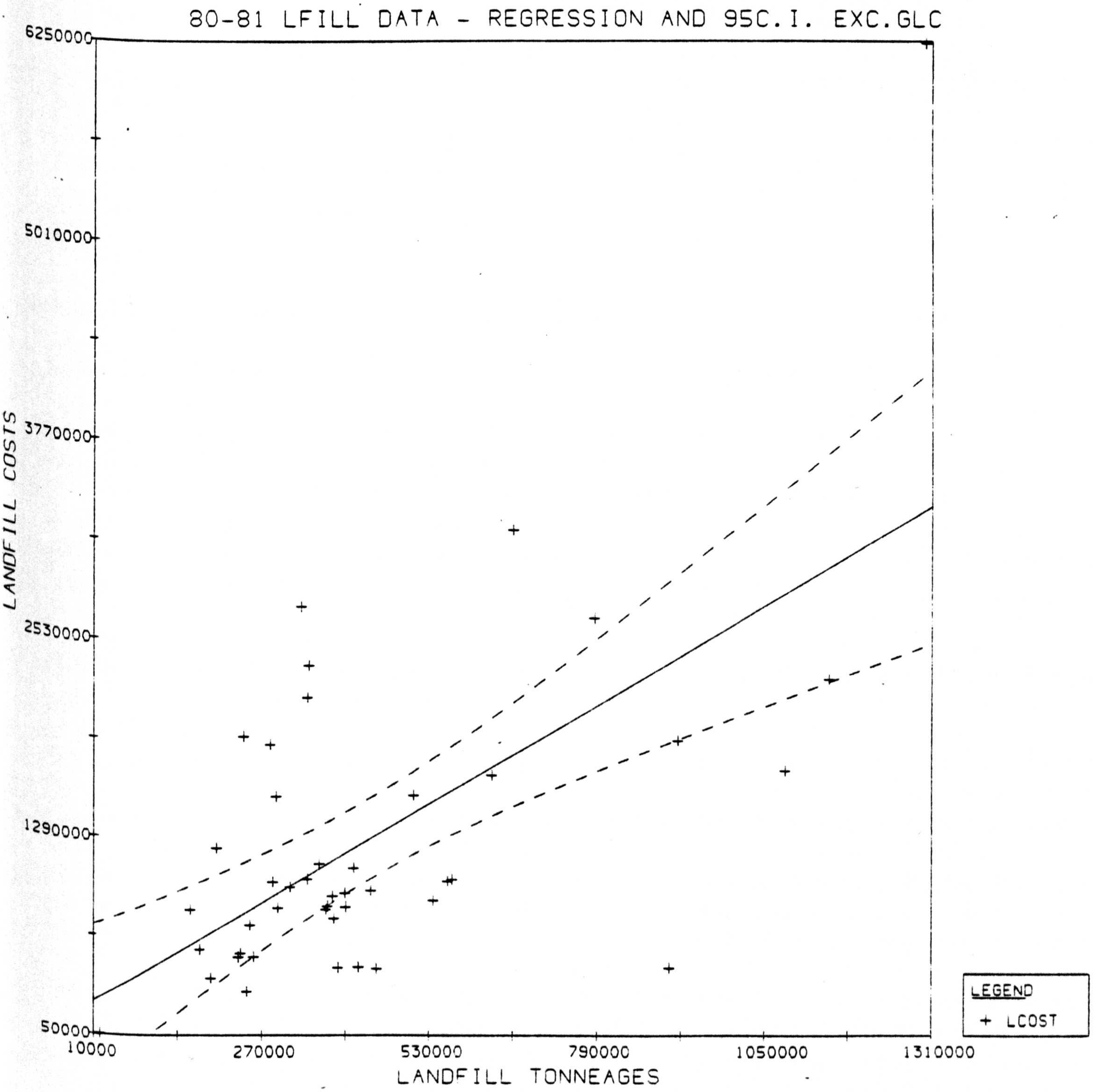
75-6 LFILL DATA - REGRESSION AND 95C.I. EXC. GLC
1410000
1130000
850000
570000
290000
10000
LANDFILL COSTS
10000
290000
570000
850000
1130000
1410000
LANDFILL TONNEAGES
LEGEND
+ LCOST


76-7 LFILL DATA - REGRESSION AND 95C.I. EXC. GLC
y = .63x + [illegible]
LANDFILL COSTS
1710000
1370000
1030000
690000
350000
10000
0
300000
600000
900000
1200000
1500000
LANDFILL TONNEAGES
LEGEND
+ LCOST


77-8 LFILL DATA - REGRESSION AND 95C.I. EXC. GLC
LANDFILL COSTS
2120000
1700000
1280000
860000
440000
20000
10000
290000
570000
850000
1130000
1410000
LANDFILL TONNEAGES
LEGEND
+ LCOST


78-9 LFILL DATA - REGRESSION AND 95C.I. EXC. GLC
LANDFILL COSTS
3000000
2400000
1800000
1200000
600000
0
20000
350000
700000
1040000
1380000
1720000
LANDFILL TONNEAGES
LEGEND
+ LCOST


79-80 LFILL DATA - REGRESSION AND 95C.I. EXC.GLC
6000000
4800000
3600000
2400000
1200000
0
LANDFILL COSTS
40000
340000
640000
940000
1240000
1540000
LANDFILL TONNEAGES
LEGEND
+ LCOST


80-81 LFILL DATA - REGRESSION AND 95C.I. EXC.GLC
LANDFILL COSTS
6250000
5010000
3770000
2530000
1290000
50000
LANDFILL TONNEAGES
10000
270000
530000
790000
1050000
1310000
LEGEND
+ LCOST

APPENDIX 5C

Scale Factors: Cost/Capacity Ratio Estimating Technique

Appendix 5C

Scale Factors: Cost/Capacity Ratio Estimating Technique

Economy of scale is usually represented by the equation:

$$\frac{C_1}{C_2} = \left(\frac{Q_1}{Q_2}\right)^x \qquad \ldots\ldots\ldots\ldots\ldots \qquad \text{(Eq. 5C.1)}$$

where C_1 is the total annual operating cost for a particular disposal method in authority 1.

C_2 is the total annual operating cost for a particular disposal method in authority 2.

Q_1 is the total annual tonnage handled by a particular disposal method in authority 1.

Q_2 is the total annual tonnage handled by a particular disposal method in authority 2.

x is the scale factor; when $x \longrightarrow o$ costs only marginally increase with capacity.

when $o < x < 1$ Economy of scale where $x \longrightarrow 1$ represents decreasing economies.

when $x = 1$ no economy of scale

$x > 1$ Diseconomy of scale where $x \longrightarrow 1$ represents decreasing diseconomies.

Equation 5C.1can be transformed into a straight line form by taking logs:

$$\text{Log}\left(\frac{C_1}{C_2}\right) = x \log\left(\frac{Q_1}{Q_2}\right) \qquad \ldots\ldots\ldots\ldots\ldots \qquad \text{(Eq. 5C.2)}$$

Thus the slope of this equation $\equiv x \equiv$ scale factor.

Therefore, as shown in Equation 5C.2 by evaluating the log derivatives of the original cost and tonneage data, in each case, a value for x can be determined. Fig. 5C.1 exhibits a graphical interpretation of the scale factors discussed above. In other studies this method has been used to evaluate capital costs; in this work operating costs are used.

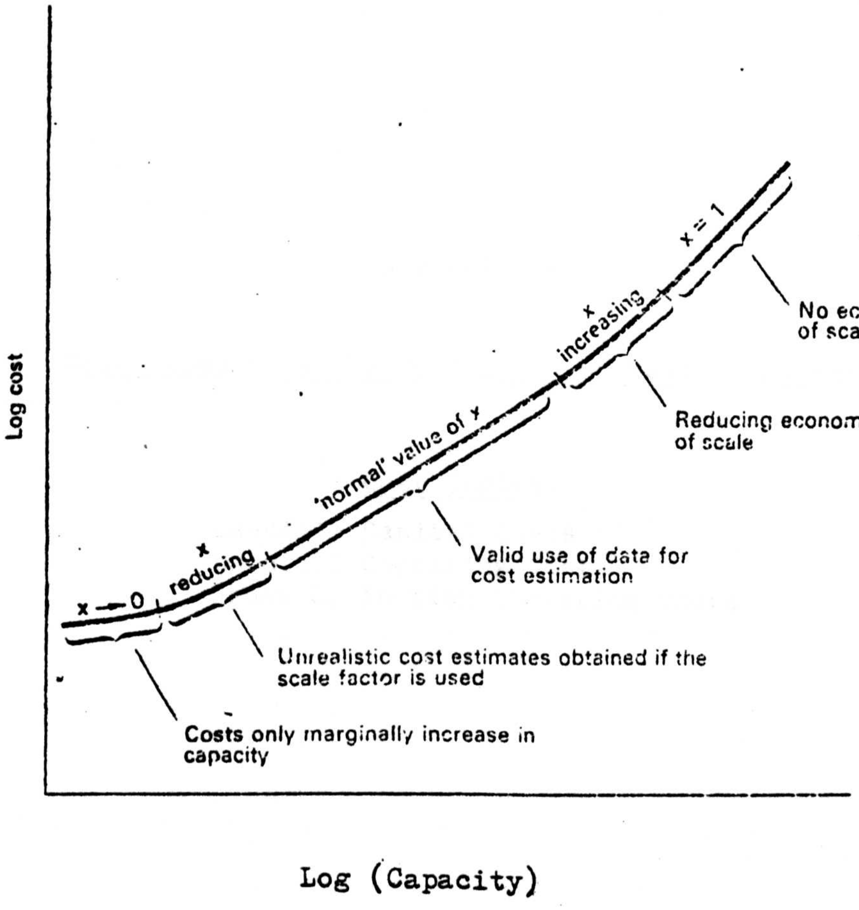


Fig 5C.1 Economy of scale and variations in scale factors. (after Bridgwater and Mumford, 1979)

APPENDIX 5D

Data Supporting the Derivation of Waste Management

Cost Indices

Landfill Capital Costs
Landfill Operating Costs
Urban Collection Operating Costs

TABLE 5D.1 Urban Collection Operating Cost Index

Financial Year / Component Cost	COSTS (£/round/y)*				COMPONENT INDICES			
	77/78	78/79	79/80	80/81	77/78	78/79	79/80	80/81
Fuel	178	188	212	242	4.4	4.6	5.2	6.0
Vehicle Maintenace Labour	208	219	234	274	5.1	5.4	5.7	6.7
Spares	187	199	217	209	3.8	4.0	4.4	4.2
Tyres	44	47	53	56	1.0	1.1	1.2	1.3
Driver	568	600	641	750	13.9	14.7	15.7	18.4
Loader	1568	1656	1769	2070	38.3	40.4	43.2	50.6
Supplies	482	509	589	636	11.8	12.5	14.4	15.6
Vehicle Licence	94	98	104	120	2.2	2.3	2.4	2.8
Depot Costs	204	227	268	300	5.6	6.2	7.4	8.2
Admin.	589	623	693	748	13.9	14.7	16.4	17.7
Urban Collection operating Cost Index**					100	105.9	116.0	131.5

* All costs deflated from 80/81 values, excludes capital charges. The cost indices in Table 5E.2 were used to deflate the 80/81 costs.

** Based on an urban collection authority of $200Km^2$, 250 t/round/y, using kerbside sack collection

Conversion Factors for other sizes of authority and collection methods

Methods	Km^2		
	100	200	300
Kerbside Sack	0.90	1.00	1.08
Kerbside Bin	0.80	0.90	0.98
Backdoor Sack	1.08	1.20	1.30
Backdoor Skep	0.96	-	-
Backdoor Bin	0.94	1.00	1.08

TABLE 5D.2: <u>Landfill Capital Cost Index</u>

Component Cost \ Financial Year	COSTS (£)*				COMPONENT INDICES			
	77/78	78/79	79/80	80/81	77/78	78/79	79/80	80/81
Site Survey	7600	8600	10400	12400	8.9	10.1	12.2	14.5
Buildings and Civils	15400	17500	21200	25300	18.1	20.6	24.9	29.7
Access Road	12400	13500	18500	21600	15.5	16.9	23.1	27.0
Site Preparations	11100	12000	14200	15500	11.1	12.0	14.2	15.5
Mobile Plant	52000	57000	62900	65000	46.4	50.9	56.1	58.0
Landfill Capital Cost Index**					100	110.5	130.5	144.7

* All costs deflated from 80/81 values, Land costs are excluded, no large scale leachate treatment or gas allevation. The cost indices in Table 5E.1 were used to deflate the 80/81 costs.

** Based on a landfill site with a throughput of 150 t/d.

<u>Conversion Factors to other sizes of Operations</u>

t/d	50	100	200	300	500
	0.40	0.76	1.27	1.30	1.72

TABLE 5D.3: Landfill Operating Cost Index

Financial Year / Component Cost	COSTS (£)*				COMPONENT INDICES			
	77/78	78/79	79/80	80/81	77/78	78/79	79/80	80/81
Fuel	2000	2100	2400	2700	5.7	6.0	6.8	7.7
Vehicle Maintenance Labour	2700	2800	3000	3500	7.3	7.6	8.1	9.5
Spares	1150	1250	1350	1300	2.8	3.0	3.3	3.2
Tyres	3100	3400	3800	4000	8.4	9.2	10.3	10.8
Vehicle Licence	200	250	250	300	0.6	0.8	0.8	0.9
Labour	15700	16600	17700	20700	43.8	46.3	49.4	57.7
Supervisory Labour	2000	2200	2300	2700	5.7	5.2	6.6	7.7
Materials	600	650	750	800	1.6	1.7	2.0	2.1
Services	150	150	150	200	0.4	0.4	0.4	0.5
Building Maintenance	350	400	450	500	1.1	1.3	1.4	1.6
Admin.	3400	3600	4000	4300	9.2	9.7	10.8	11.6
Rent	5300	5300	5300	5300	11.3	11.3	11.3	11.3
Rates	700	700	750	1000	2.1	2.1	2.3	3.0
Landfill Operating Cost Index**					100	104.6	113.5	127.6

Conversion factors to other sizes of operation

t/d	50	100	200	300	500
	0.40	0.27	1.10	1.50	1.90

* All costs deflated from 80/81 values, excludes capital charges and cover charge. The cost indices in Table 5E.2 were used to deflate the 80/81 costs.

** Based on a landfill site with a throughput of 150 t/d

APPENDIX 5E

Government Cost Indices used in this Research

TABLE 5E.1: Cost Indices Used to Convert Capital Costs to the Base Date (March 1981)

Component Cost	% Reduction in Costs Based on March 1981						Source
	75/76	76/77	77/78	78/79	79/80	80/81	
Building	+125	+81.4	+64.0	+44.4	+19.2	0	Work Category 2/11 - Brickwork PAF series 2
Access Roads	+117	+90.4	+73.6	+59.6	+16.7	0	Work Category 2/47 - Bituminous surfacing. PAF series 2
Site Drainage	+ 90.0	+65.2	+53.2	+38.7	+15.9	0	Work Category 2/2 - Site Prep. PAF series 2
Gas Alleviation	+93.9	+61.7	+40.6	+25.7	+ 7.8	0	MLH 333/3 Wholesale Prices Indices B.B. various ed.
Fencing	+73.0	+46.6	+39.5	+29.1	+ 8.8	0	Work Category 2/46 - Fencing PAF series 2
Stores & new equipment	+111	+75.1	+52.2	+34.6	+ 7.8	0	MLH 301 Wholesale Prices Indices B.B. various ed.
Mobile Plant	+ 69.0	+40.6	+25.0	+14.1	+ 3.4	0	MLH 336 Wholesale prices Indices B.B. various ed.
Landscaping (Close Down Act.)	+ 88.0	+60.7	+46.9	+34.3	+12.6	0	Work Category 2/48 - Soft Landscaping PAF series 2
Demolition (Close Down Act.)	+ 91.0	+67.5	+55.3	+40.4	+17.2	0	Work Category 2/1 - Demolition PAF series 2

P.A.F. - Price Adjustment Formula, Series 2. P.S.A., D.O.E. HMSO:London

M.L.H. - Minimum List Heading

B.B. - British Business, Department of Industry

OPERATING COSTS

TABLE 5E.2: Cost Indices Used to Convert Operating Costs to the Base Date (March 1981)

	% reduction in costs based on March 1981				
Component Cost	77/78	78/79	79/80	80/81	Source
Cover	35	24	14	0	MLH 103 BB
Fuel and Labour	36	29	14	0	MLH 262 BB
Maintenance Lab.	32	25	17	0	Table 18.7 MDS
Spares	12	5	(4)	0	MLH 336 BB
Tyres	27	19	5	0	MLH 491/1 BB
Depot Costs	47	32	12	0	No index found. General inflation rate used.
Materials	32	25	8	0	Table 18.11 MDS
Services	35	30	23	0	Table 2 ET
Building Maint.	36	30	9	0	MLH 469/2 BB
Site Rent/Lease	0	0	0	0	Rent fixed by contract. Assumed stable.
Rates	44	41	33	0	Deduced from the "Total Rateable value of Public utilities" RRS
Dept. Admin.	27	20	8	0	Table 18.7 MDS
Vehicle Licences	27	23	15.5	0	Table 18.10 MDS
Vehicle Insurance					Table 18.9 MDS
Driver/Loader/ Manual Labour	32	25	17	0	Table 18.7 MDS
Supervisory Lab.	32	25	17	0	Table 18.7 MDS
Electricity	49	41	22	0	Table 2 ET
Transfer and Treatment Equipment	47	32	12	0	No index found. General inflation rate used.

MLH	Minimum List Heading
BB	British Business, D.O. Industry
MDS	Monthly Digest of Statistics, Central Statistical Office (CSO)
ET	Energy Trends, D.O. Energy
RRS	Rating Review for Scotland, CIPFA Scotland
( )	% increase in costs based on March 1981

APPENDIX ACCOMPANYING CHAPTER 6

APPENDIX 6A

Sources of information used in this research

Technical and financial information was obtained from the following local authorities and organisations.

English County Councils

Avon
Cheshire
Cleveland
Cornwall
County Durham
Dorset
East Sussex
Greater London Council
Greater Manchester Council
Hampshire
Hertfordshire
Humberside
Isle of Wight
Kent
Lanacashire
Leicestershire
Merseyside
Norfolk
Northamptonshire
Northumberland
Oxfordshire
Somerset
South Yorkshire
Staffordshire
Suffolk
Surrey
Tyne and Wear
West Midlands
West Sussex

Scottish District Councils

Aberdeen
Annandale
Clackmannan
Clydesdale
Cumbernauld
Cunninghame
Dumbarton
Dundee
Dunfermline
East Kilbride
East Lothian
Eastwood
Edinburgh
Etterick and Lauderdale
Falkirk
Glasgow
Gordon
Inverness
Lochaber
Motherwell
Nithdale
Orkney Islands

Shetland Islands
Stirling
Strathkelvin
Sutherland
West Lothian

English District Councils

Brighton
Carlisle
Greenwich London Borough
Hove
Lambeth London Borough
Middlesborough
Mole Valley
Newcastle
North Norfolk
Nuneaton and Bedworth
Oxford
Reading
Tynedale
Vale of White Horse

Northern Ireland District Council

Lisburn

Welsh District Councils

Aberconwy
Meirionnydd
Monmouth
Newport
Radnor
Rhuddlan
Vale of Glamorgan

Manufacturers, Suppliers and Contractors

American Hoist UK	(balers)
Amey Roadstone	(landfill contractor)
Anderson-Grice	(overhead cranes)
Bomag GB	(landfill compactors)
Bowmaker Plant	(landfill plant supplier)
British Jeffrey Diamond	(pulverisers)
Brown Lennox	(pulverisers)
Davy Instruments	(weighing scales)
Dust Control Equipment	(dust suppression)
Dust Suppression International	
Glover, Webb and Liversidge	(collection vehicles)
Haul Waste	(waste disposal contractor)
Hestair Dennis	(collection vehicles)
Hyster Europe	(landfill compactors)
International Baler Corporation	
Jack Allen Motor Bodies	(collection vehicles)
Lacre	(collection vehicles)
Lindermann UK	(balers)
Motherwell Bridge Tacol	(civil engineering contractor)
Norba	(collection vehicles)

Peabody Holmes	(pulverisers and compactors)
Portakabin	(portable buildings)
Powell Duffryn Engineering	(stationary compactors)
Scapa Engineering	(collection vehicles)
Shelvoke and Drewry	(collection vehicles)
Simsons of Edinburgh	(pulveriser agent)
SLD Olding	(landfill compactor supplier)
Tollemache	(pulverisers)
Tozer, Kemsley and Millbourn Trading	(landfill compactor supplier)
Vapsco	(stationary compactors)
Vicker Logemann	(balers)
Volvo BM	(landfill site plant)
WG Cannon Air Engineering	(dust suppression)
William Hemmings	(waste disposal contractor)
Youngman System Building	(portable buildings)

Other Organisations

Chartered Institute of Public and Finance Accountants
County Surveyor's Society
Industry Committee for Packaging and the Environment
Institute of Wastes Management
Local Government Operational Research Unit
National Association of Waste Disposal Contractors
North West Water Authority
Property Services Agency, Department of the Environment
University of Aston
Water Research Centre

APPENDIX 6B

Examples of the Cost Sheets used to Collate Financial and Technical Data for each Disposal Method and a Comprehensive List of Items Included under each Component Cost on these Sheets

"TYPICAL" COLLECTION ROUND

For a crew size:
Fiscal Year:
Name of Authority:
Average haul distance to tip:
Method of Collection:

Arisings

Tonneages Collected/day/vehicle:

No. of Domestic Refuse Collection Vehicles:

No. of Collection rounds/day/vehicle:

Capital Costs

Route Planning - Cost

Vehicle Purchase - Description of vehicle and capacity:
- Lifetime:
- Year of purchase:
- Cost of Purchase:
(for Lease charge/y see below)

Operating Costs

Vehicle - Fuel and Lub cost/y:
- Maintenance cost/y:
- Spares cost/y:
- Tyres cost/y:

Sacks, Skeps and Supplies - Describe:
- Cost/y:

Labour - Crew size:
- Driver basic wage cost/y:
- On-costs (inc. OT) percentage of basic:
Value/y:
- Workman basic wage cost/y:
- On-costs (inc. OT) percentage of basic:
Value/y:

Vehicle Lease/ Debt Charges - Describe:
- Cost/y:

Vehicle Insurance & Licences - Cost/y:

Departmental Admin.
Charge - Cost/y:

Revenues (if any)

Describe sources of revenue:

Value of each/y:

TRANSFER STATION

Financial Year:
Name of Authority:

Throughput

Tonneage Input/day:
Battery Limit or Green Field Site:
Nature of transferal op:
Haul distance:

Capital Costs
Site Acquisition

Land - Year of purchase:
- Cost of purchase:

Site Survey & Design - Cost

Site Preparation

Transfer & Treatment Equipment - Describe:
- Rated capacity:
- Direct or Indirect (Storage) Transfer:
- Lifetime:
- Year of purchase:
- Cost of purchase:
(for Lease charge/y see below)

Buildings & Civils - Year of construction:
- Desc. of buildings:
- Cost of Construction:
- Lifetime:

Other Ancillary Equipment
- Describe:
- Year of installation:
- Cost of installation:
- Lifetime:

Bulk Transporters (for each)
- No. of Tractors & Bodies/Wagons/Barges:
- Method of Transport:
- Year of purchase:
- Cost of purchase:
- Lifetime
  (for Lease charge/y see below)

Operating Costs

Density of refuse achieved in bulk transporters:

Transfer & Treatment Maint.
- Describe:
- Cost/y:

Bulk Transporters
- Fuel and Lub cost/y:
- Maintenance cost/y:
- Spares cost/y:
- Tyres cost/y:

Electricity
- Quantity:
- Cost/y:

Manual Labour
- No. of men:
- Basic wage cost/y:
- On-costs (inc. OT) percentage of basic:
  Value/y:

Supervisory Staff
- No. of men:
- Basic wage cost/y:
- On-cost (inc. OT) percentage of basic:
  Value/y:

Other Materials
- Describe:
- Cost/y:

Other Services (GW, Tel)
- Quantities:
- Cost/y:

Buildings & Other Maint.
- Cost/y:

Departmental Admin. Charge - What percentage:
- Cost/y:

Rates - Cost/y:

Site Rent/Lease/ Debt Charges - Describe:
- Cost/y:

Vehicle & Plant Lease/Debt Charges Cost/y:

Vehicle Insurance and Licences - Cost/y:

Revenue

Describe sources of revenue:

Value of each/y:

Closure Costs

Year of expected closure:

Close down activities:

Cost:

DISPOSAL SITE

Financial Year:
Name of Authority:

Throughput

Tonneage Input/day:

Site Lifetime (Total):

Direct or Transfered Haul:

Battery Limit or Green Field Site:

Average Haul Distance:

Capital Costs
Site Acquisition

Land
- Year of purchase or rental:
- Cost of purchase:
  (for rental/y see overleaf)
- Airspace (volume):

Site Survey - Cost:

Site Preparation

Buildings & Civils - Year of construction
- Details of buildings:
- Cost of construction
- Lifetime:

Access Road - Year of construction:
- Cost of construction:

Special Engineering - Leachate pollution/drainage Works
description:
Cost:
- Gas collection/alleviation works
description:
Cost:

Plant (for each) - Description and Traction:
- Lifetime:
- Year of purchase:
- Cost of purchase:
(for lease/y see below)

Other Prep Costs (fencing, stores etc.) - Cost:

Operating Costs

Method of refuse emplacement - Description:
- Initial effective density sought:

Site Road/Cover Materials - Quantity brought in/y:
- Describe:
- Cost/y:

Plant (for each) - Fuel and Lub cost/y:
- Maintenance cost/y:
- Spares cost/y:
- Tyres cost/y:

Manual Labour - No. of men:
- Basic wage cost/y:
- On-costs (inc. OT) percentage of basic:
Value/y:

Supervisory Staff - No. of men:

- Salary cost/y:

- On-costs (inc. OT) percentage of basic:

Value/y:

Other Materials - Describe:

- Cost/y:

Services (GWE) - Quantities:

- Cost/y:

Buildings & Other Maintenance - Cost/y:

Departmental Admin. Charge - What percentage:

- Cost/y:

Rates - Cost/y:

Site Rent/Lease Charges/Debt Charges - Describe:

- Cost/y:

Haul Subsidies - Mileage Threshold:

- Cost/y:

Vehicle & Plant Lease/Debt Charges Cost/y:

Vehicle Insurance & Licence - Cost/y:

Revenues

Describe sources of revenue:

Value of each/y:

Closure Costs

Year of expected closure:

Close down activities:

Cost:

DEFINITION OF EACH CAPITAL COST

Land:	The purchase of a site where direct acquisition has been chosen. This criterion would also include any legal and agent fees incurred.
Site Survey:	Includes public enquiry costs, topographical or aerial surveys, geological, hydrogeological and civil engineering plans, architect fees, formulation of tipping plan and landscaping plans.
Route Planning:	For a new collection round this would include Work Study Department and route planners costs, any enquiry costs, publicity costs and any legal fees incurred.
Buildings and Costs:	Construction of buildings and tipping apron for treatment equipment, offices, amenity blocks, store rooms, garaging and service bays where necessary. Also associated earthworks and other civil engineering.
Access Road:	Construction of a new disposal site access road or the improvement of an existing one. This would also include sidings or dock facilities were rail or river haul are used.
Special Engineering Leachate and/or Drainage:	Includes culverting streams, digging interception trenches and installing drains, liners, leachate treatment facilities and inspection wells.
Special Engineering Gas Alleviation and/or Collection:	Includes digging wells and laying piping for gas abstraction, installing liners and treatment facilities, digging and preparing alleviation trenches.

Other Disposal Site Preparation Costs:	Includes boundary fencing and markers, information boards, new equipment and stores purchase, landscaping costs, and where necessary wheel washing equipment and minor road improvements to the surrounding road system.
Transfer and Treatment Equipment:	Major items of transfer equipment, i.e. baler, pulveriser or compactor, storage bunkers and associated electrical switchgear.
Other Ancillary Equipment	All the periphery mechanical and electrical equipment required to make the transfer station operational. Includes conveyors, control equipment, cables and piping, cranes and other handling equipment where applicable, security and safety equipment, fencing, amenity block equipment, dust control.
Site Mobile Plant:	Purchase of site machinery and additional items such as safety equipment, tools and painting in the authority's livery.
Bulk Transporters:	Purchase of tractive unit(s) and trailers or containers and additional items as included in "Site Mobile Plant". This criterion can also include the purchase of railway wagons, barges, slave vehicles and mobile shovels.
Collection Vehicle Purchase:	Purchase of collection vehicle and additional items as outlined in "Site Mobile Plant".

DEFINITION OF EACH OPERATING COST

Site Road and Cover Material	Any material brought to the site for use in site road construction or as daily cover.
Site Plant Fuel and Lubricants:	Diesel or petrol and lubricants used by mobile site plant during site operations.
Site Plant Maintenance:	Planned or emergency maintenance costs incurred by mobile site plant, including any internal or external mechanics' labour costs, garage services, temporary replacement vehicle hire, testing and inspections.
Site Plant Spares:	The cost of replacement parts for mobile site plant necessary for either planned or emergency maintenance.
Site Plant Tyres/Tracks/ Wheels:	Includes any specific maintenance, repair or replacement necessary to the mobile site plant's traction.
Bulk Transporter Fuel and Lubricants	Diesel and lubricants used by the bulk transporters.
Bulk Transporter Maintenance:	As for "Site Plant Maintenance".
Bulk Transporter Spares:	As for "Site Plant Spares".
Bulk Transporter Tyres:	As for "Site Plant Tyres".
Collection Vehicle Fuel & Lubricants:	Fuel and lubricants used by a collection vehicle on a municipal refuse collection round of average length in a particular district. Costs for bulky, special or civil amenity collections are excluded.

Collection Vehicle Maintenance:	As for "Site Plant Maintenance". Municipal refuse collection only.
Collection Vehicle Spares:	As for "Site Plant Spares". Municipal refuse collection only.
Collection Vehicle Tyres:	As for "Site Plant Tyres". Municipal refuse collection only.
Transfer Station Electricity:	Includes only that proportion of the total quantity of electricity consumed which is used by the transfer and treatment equipment. It excludes electricity used for heating, lighting and amenities.
Baling Wire (Wire-tying balers):	Cost of baling wire used to bind the bales.
Transfer and Treatment Equipment Maintenance:	Includes planned or emergency maintenance incurred by the static plant and equipment at a transfer station which is directly concerned with handling the refuse. Includes any internal or external engineers' labour costs, temporary replacement or by-pass measures, testing and inspections. This includes operations such as: Ram servicing, maintenance of facing plates and bearings, hydraulics and switchgear.
Collection - Sacks skeps and other Collection Supplies:	Includes paper or plastic sack costs, new skeps, bins or bulk containers, disinfectant, protective clothing used on a residential domestic refuse collection round.

Manual Labour Basic Wage:	The nationally agreed basic wage for a driver, loader or manual worker.
Manual Labour On-costs:	Additional costs above the basic wage that an employer incurs as a result of employing each man. This includes, bonus, overtime, pension contribution, superannuation, employers NI, sick pay provision.
Supervisory Labour Basic Wage:	Supervisory labour is considered to represent only those men directly working at a disposal site, transfer station or on collection operations in a supervisory role. Higher management, working in central or area offices, are excluded. These are included as "Departmental Administration Costs".
Supervisory Labour On-costs:	Same as for "Manual Labour On-costs".
Other Materials	Replacement and additional purchase of tools, equipment and materials required in for the general running of a disposal site or transfer station. This also includes clothing, pest control materials, pollution control materials, fixtures and fittings, medical and safety equipment and landscape maintenance.
Other Services:	Includes the less physically tangible requirements of the general operation of a disposal site or transfer station. Includes water, gas, electricity for heating, lighting and amenities, telephone, cleaning contractors and minor requirements such as painters and signwriters.

Rates:	The amount levied by a local authority according to the imputted for the disposal site or transfer station.
Buildings and Other Maintenance:	Planned or emergency maintenance costs incurred on buildings and other items (e.g. fences and weighbridge) which are not directly involved with the physical handling of refuse. Includes internal and external builders' costs, temporary replacements, testing and inspections. Any materials used should be included under the "Materials" cost criteria above.
Departmental Administration Charge:	Includes central and/or area office running costs, higher management and supporting staffs' salaries, expenses, buildings and fixed plant insurances and related charges for the entire collection and disposal operations. It excludes vehicle insurance and licences. Departmental administration charges are usually apportioned on each site at a rate depending on that site's percentage proportion of the total department's expenditure.
Depot and Other Collection Operating Costs:	This covers any depot costs for a collection vehicle, which generally includes cleaning and preparation of the vehicle each day, a percentage of the transport managers' expenses, a portion of the capital and running expenses of the depot as well as any amenities it provides. "Other operating costs" covers minor expenditures such as periodic steam cleaning of the interior of the vehicle or repainting.

Site Rent/Lease/Debt Charges: The site of a disposal or transfer point can be either owned outright (paid for out of revenue or by loan) or leased over a fixed or indefinite period. If any of the latter 3 methods of acquisition are used, there is a subsequent annual cost incurred and is represented by this component cost. Where a site is purchased out of revenue no such annual cost is recurred although there is a corresponding opportunity cost. The opportunity cost will be treated as a debt amortized at 14% per annum.

Vehicle and Plant Lease/Debt Charges: As for "Site Rent/Lease/Debt Charges" except that the cost is also applicable to collection methods. This component cost includes all items of mobile plant, static plant and buildings. Where any item has been purchased out of revenue no such annual cost as described above is incurred although there is a corresponding opportunity cost. This opportunity cost will be treated in the same way as a debt charge and amortized at 14% per annum.

Vehicle Licences and Insurance: This cost is typically separated out in local authority records from other departmental administrative charges. It is also more liable to variation should local authority policy on vehicle capacities, traction and manufacture change.

Haul Subsidies: Only payable in England where disposal and collection functions are split between County Councils and District Councils. The county council pays the district council a locally agreed subsidy should a disposal point (site or transfer station) be greater than a locally agreed distance from each

DEFINITION OF EACH REVENUES ITEM

Disposal Revenues:	Regularly occurring disposal charges from trade depositors, sale of recovered materials, once off sale of land, equipment and buildings.
Transfer Revenues:	As for "Disposal Revenues"
Collection Revenues:	Regularly occurring collection charges from traders and other authorities under contract, once off sale of equipment. This item also includes haul subsidies to collection districts.

DEFINITION OF EACH CLOSURE COST

Disposal Closure Costs:	Purchase and spreading of final cover, seeding and landscaping, demolition and removal of buildings, removal of equipment and redundancy payments where necessary. Long term environmental monitoring.
Transfer Closure Costs:	As for "Disposal Closure Costs".
Collection Closure Costs:	None envisaged.

APPENDICES ACCOMPANYING CHAPTER 7

APPENDIX 7A

Collection

Original Data

KERBSIDE SACK: Annual Operating Cost/Round Original Data

	URBAN				RURAL
t/round/y crew size	260 1+3	270 1+3	286 1+3		104 1+2
Fuel	1970	160	177		372
Maintenance		261	121		377
Spares		314	142		
Tyres			39		53
Supplies	880	1105	462		1000
Driver	713	671	781		1011
Loaders	1737	1921	2211		2976
Vehicle Lic. & Ins.	*	83	96		216
Depot Costs	3	32	N/A		158
Dept. Admin.	21	326	N/A		226
Capital Charges	99	421	N/A		944

* Included in aggregated vehicle manning cost above

KERBSIDE BIN: Annual Operating Cost/Round Original Data

	URBAN		RURAL			
t/round/y crew size	295 1+4	317 1+3	104 1+2	364 1+3	286 1+3	260 1+2
Fuel	231	225	375	3970	892	172
Maintenance	366	482	250		1339	481
Spares		12				
Tyres		67				
Supplies	232	75	63	98	200	199
Driver	589	3456	2589	798	1680	1549
Loaders	2290			2234	4876	
Vehicle Licence & Insurance	85	24	98	*	464	92
Depot Costs	315	700	536	122	783	7
Dept. Admin.	395	1287	474	533	857	119
Capital Charges	532	429	825	*	2277	499

* Included in aggregated vehicle running cost above

BACKDOOR SKEP: Annual Operating Cost/Round Original Data

	URBAN	
t/round/y	213	206
crew size	1+4	1+5
Fuel	287	N/A
Maintenance	844	N/A
Spares		N/A
Tyres	67	N/A
Supplies	99	N/A
Driver	572	676
Loaders	1890	3127
Vehicle Lic. & Insurance	182	99
Depot Costs	84	N/A
Dept. Admin.	379	229
Capital Charges	318	600

BACKDOOR BIN: Annual Operating Cost/Round Original Data

	URBAN					RURAL		
t/round/y crew size	260 1+4	224 1+4	260 1+4	208 1+5	250 ?	390 1+3	185 1+2	246 1+3
Fuel	208	121	192	347	159	362	222	263
Maintenance	184		700		177	341		
Spares	118	287	36	757	79	182	229	234
Tyres	35	52	12	90	79	113	62	62
Supplies	43	76	300	102	N/A	218	163	79
Driver	661	989	826	1434	N/A	1579	711	589
Loaders	2268	3724	2814	2708	N/A	4222	1358	1611
Vehicle Licence & Insurance	170	108	106	172	110	148	90	16
Depot Costs	310	12	286	26	N/A	66	278	0
Dept. Admin	0	62	500	N/A	N/A	86	140	363
Capital Charges	523	N/A	500	944	800	393	360	141

BACKDOOR SACK: Annual Operating Cost/Round Original Data

	URBAN					RURAL	
t/round/y crew size	302 1+3	150 1+4	312 1+4	250 1+4	250 1+4	230 1+3	104 1+3
Fuel	400	205	342	194	1245	194	505
Maintenance	1352	311	1578	152		1442	276
Spares		326					217
Tyres				50			151
Supplies	1259	863	1692	1056	880	778	1550
Driver	1310	650	4733	778	1060	1888	1930
Loaders	3650	260		3120	3994		5419
Vehicle Licence & Insurance	340	133	219	111	*	92	50
Depot Costs	394	392	1119	112	*	248	0
Dept. Admin.	669	188	450	208	355	315	250
Capital Charges	470	236	207	397	*	631	210

* Included in the aggregated vehicle running at above

APPENDIX 7B

Collection

Descriptive Derivation of each First and Second Reduction Component Cost and the Amortization Calculation

7B.1 COLLECTION CAPITAL COSTS

In contrast to landfill or transfer operations, collection operations require a much lower capital investment. The principal item of plant being the refuse collection vehicle. The only other capital cost identified is an administrative or consultancy cost for route planning or reorganisation.

No capital cost has been included for garaging or depot facilities since these premises are generally used by several of the local authority departments. However, an operating cost to cover depot expenses and an apportionment of its capital charges has been included. This approach has had to be used due to local authorities almost never apportioning a depot capital cost to their individual collection operations. The discussion presented here should be read in conjunction with the Original Data (Appendix 7A), First Reduction Costs (Appendix 7C) and Second Reduction Costs (Appendix 7D).

7B.1.1 ROUTE PLANNING

This expenditure can vary widely. New rounds require a large initial effort not only in planning the route of the round but also in vehicle scheduling, advice to householders and union negotiation. Many union restrictive practices, inadequacies in work studying the operation and the slow nature of council decision-taking make the planning of a new round, or the reorganisation of an existing one, a more complex (and hence more expensive) task than many officials realise.

Of the authorities contacted, two had recently reorganised individual rounds, when undertaken in-house the cost had been £200, and when undertaken by external consultants, the cost was £2000. A conservative cost of £1000/round has been used in this work.

7B.1.2 VEHICLE PURCHASE AND AUTHORISATION CALCULATION

All authorities included in this work use rear-end loading (REL) collection vehicles with on-board compaction and inspite of the very wide range of tonneages collected, the sizes of vehicle purchased are remarkably similar. Internal volumes are between 11.5 and 15.3m^3 (15yd^3 to 20yd^3) and capable of conveniently holding 6t. Reported tonneages, however, range from 104t/round/y to 390t/round/y. Consequently, some authorities run vehicles permanently under-filled which are too large for their requirements (104t/round/y ≡ 2t/round/week), whereas others are either overloading their vehicles or, as suspected, over-estimating the tonneages collected (390t/round/y ≡ 7.5t/round/week). A purchase price of £30000 per vehicle has been used and any price variation between the two capacities mentioned above is very small.

AMORTISATION

The vehicle is assumed to be bought by loan over 5 years at 14% interest per annum. Annual capital charges are calculated by amortisation:

$$\text{using} \quad a = \frac{PVat}{PVIF_a}$$

where a: the annual repayment

PVat: Present Value of the annuity (sum borrowed)

$PVIF_a$: Present value of an annuity, derived from financial tables with reference to the appropriate interest rate and length of loan

$$£8738 = \frac{30000}{3.4331}$$

Annual repayments on a vehicle are £8738. This value must be divided by the number of rounds that the vehicle services to derive the capital charge applicable for each collection round.

The route planning cost is not assumed to have been financed by outside debt and hence there are no annual capital charges for this expenditure. Since route planning is a small cost by comparison to vehicle purchase and only an occasional expense, it is assumed to be financed from the revenue budget.

7B.2 COLLECTION OPERATING COSTS

Ten component costs were identified which together comprise the total operating cost (excluding capital charges). Data on each of these costs were collated from local authorities and are discussed in detail in this chapter.

7B.2.1 VEHICLE RUNNING COSTS

In the first reduction the vehicle running costs supplied by some authorities were aggregated. Subsequently, these were separated out into their individual component costs (ie. fuel, maintenance labour, spares, tyres). This was achieved by taking the mean value of each component cost from those authorities which supplied non-aggregated data and calculating its percentage proportion of the total cost. These percentages were then used to separate the aggregated figures.

<u>Example calculation: Kerbside Sack</u>

	URBAN			RURAL		
Cost Component	Non-aggregated values from Original Data*	Mean Annual Cost(£)	%	Non-aggregated values from Original Data*	Mean Annual Cost(£)	%
Fuel	160 171	169	31.2	372	372	43.2
Maintenance Labour	261 121	191	35.4	377	377	49.8
Spares	142	146	26.2			
Tyres	39	39	7.2	53	53	7.0
		541			802	

* Detailed in Appendix 7A

A summary of these mean values and their percentage proportion for all collection methods is given in Table 7B.1. The relative difference between each urban and rural running cost is given in Table 7B.2.

7B.2.2. FUEL COSTS

Low R^2 values were found for the first reduction regressions of fuel cost with tonneage, except in one case. It was then considered that fuel cost is more likely to be related to distance travelled, which in turn for a given size of load is related to the bin density and hence the area of the round. Thus, the larger the area (and therefore lower the bin density), the greater the distance travelled and fuel consumed. Thus, fuel costs will be higher in the more extensive authorities. Such a relationship between area and fuel consumption can reasonably be expected to differ for each method of collection.

Ideally, the mean area of a round in each particular authority would have been used, however, this was not possible to obtain. Assuming each round in an authority is on average approximately equal in area to every other, then the area of the total district is directly related, so this was used instead.

For each authority the first reduction fuel cost was divided by the districts' area to derive a resultant fuel cost:area ratio. A separate mean fuel cost:area ratio and SD was calculated for each collection method and in all except one case they were found to be significant at the 10% level. There was also found a difference at this level between rural and urban operations employing the same collection methods (except for backdoor bin) (see the analysis of variance calculations below). A summary of the fuel cost:area ratios calculated are given in Table 7B.3 and the mean values for each method were used to calculate the second reduction fuel costs.

With reference to Table 7B.3 the collection methods can be ranked in order of least fuel cost, ie

<u>URBAN</u>	Kerbside Bin	1.19	(£/round/Km^2)	0.14	Kerbside Bin	<u>RURAL</u>
	Kerbside Sack	1.21		0.24	Kerbside Sack	
	Backdoor Bin	1.31		0.25	Backdoor Sack	
	Backdoor Sack	1.68		0.33	Backdoor Bin	

Although these calculations are based on small sample sizes the findings are supported by a series of "analyses of variance" performed on them.

TABLE 7B.1: Summary of each Mean Annual Vehicle Running Cost per Round for the Collection Methods Studied and the Corresponding Percentage Proportion

Criteria		URBAN Kerbside Sack	URBAN Kerbside Bin*	URBAN Backdoor Sack	URBAN Backdoor* Skep	URBAN Backdoor Bin	RURAL Kerbside Sack*	RURAL Kerbside Bin	RURAL Backdoor* Sack	RURAL Backdoor Skep	RURAL Backdoor Bin
Fuel	Mean Annual Cost (£)	169	228	242	287	199	327	480	350	No Information Available	370
	%	31.2	28.9	36.0	24.0	38.9	43.2	41.0	35.2		37.3
Maintenance	Mean Annual Cost (£)	191	482	381	844	181	377	690	276		341
Labour	%	35.4	61.1	56.6	70.4	35.4	49.8	59.0	27.8		34.4
Spares	Mean Annual Cost (£)	142	12	↓	↓	78	↓	↓	217		182
	%	26.2	1.5		↓	15.2	↓	↓	21.8		18.3
Tyres	Mean Annual Cost (£)	39	67	50	67	54	53	↓	151		99
	%	7.2	8.5	7.4	5.6	10.5	7.0	↓	15.2		10.0
Mean Annual Vehicle Running Cost		541	789	673	1198	512	757	1170	994		992

* Findings considered tentative

TABLE 7B.2: Comparison Between each Urban and Rural Mean Annual Vehicle Running Cost per Round for the Collection Methods Studied and the Corresponding Percentage Difference

Criteria	Kerbside Sack			Kerbside Bin			Backdoor Sack			Backdoor Bin		
	Urban Mean Annual Cost	Rural Mean Annual Cost	% Δ w.r.t. urban	Urban Mean Annual Cost	Rural Mean Annual cost	% Δ w.r.t. urban	Urban Mean Annual Cost	Rural Mean Annual Cost	% Δ w.r.t. urban	Urban Mean Annual Cost	Rural Mean Annual Cost	% Δ w.r.t urban
Fuel	169	327	+ 93.5	228	480	+ 110	242	350	+ 44.6	199	370	+ 85.9
Maintenance Lab.	191	377	+ 13.2	482	690	+ 23.0	381	276	+ 29.4	181	341	+ 88.4
Spares	142	↓	↓	12	↓	↓	↓	217	↓	78	182	+ 133
Tyres	39	53	+ 35.9	67	↓	↓	50	151	+ 202	54	99	+ 83.3
Mean Annual Vehicle Running Cost	541	757	+ 39.9	789	1170	+ 48.3	673	994	+ 47.7	512	992	+ 93.8

TABLE 7B.3: Summary of the Fuel Cost;area Ratios Calculated for each Collection Method

	URBAN			
	Kerbside Sack	Kerbside Bin	Backdoor Sack ①	Backdoor Bin ②
	Fuel Cost/Round Km^2	Fuel Cost/Round Km^2	Fuel Cost/Round Km^2	Fuel Cost/Round Km^2
Individual Authorities	2.04	1.16	2.22	1.86
	0.99	1.22	2.17	1.53
	0.60		1.12	0.53
			1.20	
Mean/SD	1.21 0.74*	1.19 0.04**	1.68 0.60*	1.31 0.69*
	RURAL			
Individual Authorities	0.24	0.17 ②	0.14	0.45
		0.11	0.35	0.10
				0.43
Mean/SD	0.24 -	0.14 0.04*	0.25 0.15*	0.33 0.20*

* SD significant at the 10% level

** SD significant at the 5% level

① one authority excluded-very high seasonal fluctuations

② two authorities excluded-very high seasonal fluctuations

Analyses of variance conducted on the values in Table 7B.3 found:

(i) No significant difference at either the 5 or 10% levels between the 4 urban methods.

(ii) No significant difference at either the 5 or 10% levels between the 4 rural methods.

This suggests (together with analyses iv to vii) that it may be possible to use a single fuel value for all urban methods and a single value for all rural methods. However, larger sample sizes would be required to verify this hypothesis. Consequently, in this work separate values were used instead.

(iii) A significant difference at the 1% level was found between all urban and all rural methods.

This supports earlier observations (e.g. Loram, 1978) in which fuel costs between these two types of authority were found to be dissimilar.

Analyses between operational techniques; i.e. backdoor, kerbside, bin and sack operations:

(iv) No significant difference at either the 5 or 10% levels between urban backdoor and urban kerbside methods.

(v) No significant difference at either the 5 or 10% levels between urban sack and urban bin methods.

(vi) No significant difference at either the 5 or 10% levels between rural backdoor and rural kerbside methods.

(vii) No significant difference at either the 5 or 10% levels between rural sack and rural bin methods.

Further analyses were conducted on the fuel values for urban and rural authorities using the same method. In support of analysis (iii), significant differences were found for three of the four methods studied.

(viii) A significant difference at the 5% level was found between urban and rural kerbside bin.

(ix) A significant difference at the 5% level was found between urban and rural backdoor sack.

(x) A significant difference at the 10% level was found between urban and rural backdoor bin.

(xi) No significant difference at either the 5 or 10% level was found between urban and rural kerbside sack.

7B.2.3 MAINTENANCE LABOUR, SPARES, TYRES COSTS

Using the argument that fuel costs are a measure of vehicle utilisation, then the other vehicle running costs; maintenance labour, spares and tyres, can be assumed to follow a similar relationship. Accordingly, the second reduction costs were calculated from the percentage values in Table 7B.1 and by using these figures, ratios with respect to fuel were calculated. Each ratio was then used to derive a cost function by multiplying with the fuel coefficient (outlined in Table 7.B3) for that collection method.

<u>Example Calculation (Urban Backdoor bin)</u>

	Urban Running Cost Percentages (from Table 7B.1) %	Urban Ratio w.r.t. fuel	Urban Cost Equations	
Fuel	38.9	1.0	Fuel coefficient: 1.31	$y=1.31x_{km}$
Maint. Labour	35.4	0.91	0.91 x 1.31 = 1.19	$y=1.19x_{km}$
Spares	15.2	0.39	0.39 x 1.31 = 0.51	$y=0.51x_{km}$
Tyres	10.5	0.27	0.27 x 1.31 = 0.35	$y=0.35x_{km}$

A complete set of the running cost percentages, ratios and resulting equations are given in Table 7B.4. Since each of these costs are directly related to the fuel cost, the discussion on the previous page between the collection methods for fuel are equally applicable to maintenance labour, spares and tyres costs.

Due to a small sample size for the backdoor skep method, no analysis on the vehicle running costs was made. The vehicle running costs were therefore assumed to be the same as those for backdoor sack.

TABLE 7B.4 Running Costs, Percentages, Ratios and Resulting 2nd Reduction Cost Equation for each Collection Method

	URBAN											
	Kerbside Sack			Kerbside Bin			Backdoor Sack			Backdoor Bin		
Criteria	Mean Annual Cost %	Ratio with Respect to Fuel	Cost Equation	Mean Annual Cost %	Ratio with Respect to Fuel	Cost Equation	Mean Annual Cost %	Ratio with Respect to Fuel	Cost Equation	Mean Annual Cost %	Ratio with Respect to Fuel	Cost Equation
Fuel	31.2	1.0	$1.21x_{Km}$	28.9	1.0	$1.19x_{Km}$	36.0	1.0	$1.68x_{Km}$	38.9	1.0	$1.31x_{Km}$
Maint. Labour	35.4	1.13	$1.37x_{Km}$	61.1	2.11	$2.52x_{Km}$	56.6	1.57	$2.64x_{Km}$	35.4	0.91	$1.19x_{Km}$
Spares	26.2	0.84	$1.02x_{Km}$	1.5	0.05	$0.06x_{Km}$				15.2	0.39	$0.51x_{Km}$
Tyres	7.2	0.23	$0.28x_{Km}$	8.5	0.29	$0.35x_{Km}$	7.4	0.21	$0.35x_{Km}$	10.5	0.27	$0.35x_{Km}$
	RURAL											
Fuel	43.2	1.0	$0.24x_{Km}$	41.0	1.0	$0.14x_{Km}$	35.2	1.0	$0.25x_{Km}$	37.3	1.0	$0.33x_{Km}$
Maint. Labour	49.8	1.15	$0.28x_{Km}$	59.0	1.44	$0.20x_{Km}$	27.8	0.79	$0.20x_{Km}$	34.4	0.92	$0.30x_{Km}$
Spares							21.8	0.62	$0.16x_{Km}$	18.3	0.49	$0.16x_{Km}$
Tyres	7.0	0.16	$0.04x_{Km}$				15.2	0.43	$0.11x_{Km}$	10.0	0.27	$0.09x_{Km}$

7B.2.4 SUPPLIES COSTS (supplies cost = sack/bin element + other materials element)

All of the first reduction regressions (cost with tonneage) gave low R^2 values, however, the sack methods produced R^2 values between 0.54 and 0.63, reasonably near to the 0.70 arbitrary level of acceptability. Bin methods ranged from 0.02 to 0.60 and were predominantly below 0.40. These observations suggest that sack methods may be related in someway to tonneage collected, while bin methods are independent of this variable.

Sack Element. There are several probable reasons why a clear relationship between sack costs and tonneage per round was not established. Local authorities purchase sacks in bulk and individually negotiate the price for the number of sacks required. Consequently, prices tend to fluctuate due to:

(a) the number to be purchased;
(b) the oil/paper pulp prices prvailing at the time of tendering;
(c) the number of competing manufacturers.

Thus, a range of unit costs (per 1000 sacks) were obtained during 1980/81 and when summed gave a mean value of approximately £28, ie:

Urban backdoor sack	Range £19 to £43	Mean £27.73	SD £9.25
Urban kerbside sack	£21 to £38	£28.68	£8.62

Therefore annual sack cost/round is given by:

$$\text{Mean number sacks/round/year} = \frac{\text{tonneage/round/year}}{\text{tonneage/sack}^*}$$

Thus, $\text{Mean number sacks/round/year} \times \frac{\pounds\ 28}{1000} = \text{Annual sack cost/round}$

---

* taken as 11Kg/household/week (1979 national value)

Other Materials Element (Sack Methods)

The other materials element for both sack methods was found to be approximately 5% of the total supplies cost, i.e:

Urban backdoor sack - Other Material	Mean 5.0%	0.053	Ratio withrespect to sacks
Urban kerbside sack -	Mean 4.6%	0.048	
		0.05	(i.e. 5%)

Therefore annual other materials cost/round is given by:

Other materials cost/round = 0.05 x annual sack cost/round

The supplies cost was calculated by summating the sack element and other materials element. The sack methods although empirically derived, were then regressed against tonne/round/year in the second reduction to determine the cost equation. With rural sack methods, the above analysis was not performed due to the very small sample sizes. Instead, a crude fixed cost was assumed (Table 7B.5). It is considered that if further sampling was undertaken, the rural methods would exhibit a similar relationship with tonneage to that found with the urban sack methods.

No relationships between the supplies cost and tonneage, or area of authority were established for bin methods. Instead, fixed values were calculated and applied over the entire range of sizes of operation considered. Details of the fixed values calculated are given in Table 7B.5. It is assumed that this fixed supplies cost includes both bin and other materials elements.

With reference to Table 7B.5 bin and skep costs are reasonably similar between all methods and between urban and rural operations; in the region of £100-£150/round. Rural sack costs are between eight and ten times greater over the range of tonneages studied than bins, and urban sack costs four to eight times higher. Clearly, there is a wide difference in supplies costs between sack and bin/skep methods which reflects the different nature of these collection techniques.

TABLE 7B.5 Summary of Supplies Cost Calculations for all Bin Methods and Rural Sack Methods

Criteria	URBAN		RURAL		(crude estimates)	
	Kerbside Bin and Backdoor Skep	Backdoor Bin	Kerbiside Bin	Backdoor Bin	Kerbside Sack	Backdoor Sack
Number of cases	1	4	4	3	1	2
Mean & SD (£)	①	130 116	140 70*	153 70*	1000	1164 546
Range (£)	①	43-300	63-200	79-218	-	778-1550
Rounded off value in 2nd reduction (£)	100	100	140	150	1000	1100

① Only 1 case, insufficient for separate analysis. Backdoor value used

* Significant at the 10% level

7B.2.5 DRIVER AND LOADER COSTS

Crew sizes were "fixed" for each collection method and between urban rural operations by averaging the manning levels quoted by each local authority.

Kerbside collections (bins and sacks)	Urban	1+3	(Driver + Loaders)
	Rural	1+2	
Backdoor (skeps and sacks)	Urban	1+4	
	Rural	1+3	
Backdoor (bins)	Urban	1+4	
	Rural	1+3	

Variations in these crew sizes are investigated in Chapter 7.

Drivers' wages are similar to those of mobile plant drivers in disposal operations, i.e. £7500/y (basic + 70% on costs). The cost per round is this value divided by the number of rounds per week he covers.

Loaders' wages are similar to those of disposal site workmen, i.e. £6900/y (Basic + 70% on costs). The cost per round is this value multiplied by the relevant number of loaders and divided by the number of rounds the crew services.

7B.2.6 VEHICLE LICENCES AND INSURANCE COSTS

All methods gave low R^2 values in the first reduction regressions of cost against tonne/round/year. In the absence of any conflicting argument, the costs were considered as fixed values for each method.

With regard to Table 7B.6, the vehicle licences and insurance cost/round is reasonably similar for all methods; range £71 to £201. There appears to be no trend between methods for either urban and rural

TABLE 7B.6: Summary of the Vehicle Licences and Insurance Costs for all Methods

	URBAN					RURAL				
Criteria	Kerbside Sack	Kerbside Bin	Backdoor Sack	Backdoor Skep	Backdoor Bin	Kerbside Sack	Kerbside Bin	Backdoor Sack	Backdoor Bin	Mean of Means
No. of cases	3	2	5	1	5	1	3	④ 2	3	
Mean SD(£)	93 8.9**	93②	201 104*	201①	133 34.5**	95③	95 4.5**	71 26.7	119 41.0*	122** 47.9⑤
Range (£)	83-100	②	90-340	①	106-172	③	92-98	50-92	16-148	

① Only 1 case, insufficient to do a separate analysis. Backdoor sack value used

② Only 2 cases, " " " " " Kerbside sack value used

③ Only 1 case, " " " " " Kerbside bin value used

④ Limited sample had to be used

⑤ Approximated to £120/round for each collection method

* Significant at the 10% level

** " " " 5% level

operations. However, in general, urban costs are in the upper half of this range while rural rounds are in the lower portion. This may possibly be due to the lower insurance premiums required in rural, low-risk areas.

Since the cost/round for each method is similar, the mean of all the methods, £120 has been used.

7B.2.7 DEPOT COSTS

This was by far the most difficult cost to resolve, particularly in the view of conflicting first reduction R^2 values. Not all collection authorities have their own depots, some share facilities with other departments, some have no facilities at all, but instead hold agency contracts with outside garages. The physical standard of the depot and the facilities it possesses also vary widely.

Direct regression of depot cost/round with tonne/round/year and Km^2 gave inconclusive findings. Subsequently, depot costs/round were also regressed against size of domestic collection vehicle fleet and even with the exclusion of obvious outliers low R^2 values were still obtained.

The total annual depot cost was also considered and similar regressions again proved unreliable. It was subsequently realised that a depot or the collection department portion thereof does not only have domestic collection vehicles but also bulky collection vehicles, vehicles servicing commercial and trade waste rounds, skip vehicles and supervisors' vans. This total number of vehicles was derived from the Municipal Yearbook. Thus, the total annual depot cost was regressed against the total number of collection department vehicles and for all the collection methods with an adequate sample size R^2 values > 0.70 were achieved. Depot costs calculated from these cost functions are listed in Table 7B.7.

TABLE 7B.7: Summary of the Depot Cost per Round

Collection Method	Urban Depot Cost/Round	Rural Depot Cost/Round
Kerbside Sack	988	150 ③
Kerbside Bin	311 ①	110
Backdoor - 1 trip Sack	317	150 ③
Backdoor - 1 trip Skep	311 ②	-
Backdoor - 2 trip Bin	311	110 ④

① Only 2 cases, insufficient to do a separate analysis, Backdoor bin value used

② Only 1 case, insufficient to do a separate analysis, Backdoor bin value used

③ No comparable sack method with adequate sample size, therefore limited sample sizes in both cases had to be used

④ Only 2 cases, insufficient to do a separate analysis, Kerbside bin value used

7B.2.8 DEPARTMENTAL ADMINISTRATION COST

Based on observations from authorities, administration was estimated as 15% of the total collection budget. Therefore, the departmental administration cost was calculated as 15% of the total operating cost per found (excluding capital charges). Administration costs appear to be similar for all collection methods since most local authorities that changed their collection methods after reorganisation found no need to significantly alter their administrative structure or costs. Thus, the 15% figure can be applied equally to all methods. This implies that the more expensive collection methods are costed as requiring a larger administrative effort. This is considered to be a true representation of reality.

7B.2.9 TOTAL OPERATING COST PER ROUND (EXCLUDING CAPITAL CHARGES)

The individual second reduction operating costs summated and the totals regressed against tonneage (i.e. tonne/round/year) and area of authority (Km^2). The latter cost function produced the better fit for all collection methods.

APPENDIX 7C

Collection

First Reduction Costs and Corresponding R^2 Values

First Reduction Regressions on Urban Costs - R^2 Values Annual Cost Against Annual Tonneage per Round

Criteria	Backdoor Bin		Backdoor Sack		Kerbside Sack		Kerbside Bin and Backdoor Skep
	XY	LogX LogY	XY	LogX Log Y	XY	LogX LogY	
Fuel	0.23	0.12	0.34	0.38	0.60	0.57	
Maint. Labour	0.00	0.03	0.45	0.16	0.83	0.96*	Insufficient urban cases to enable any independant analyses on these methods
Spares	0.55	0.49	↓	↓	0.86	0.96*	
Tyres	0.49	0.43	0.09	0.01	0.86	0.96*	
Supplies	0.14	0.02	0.60	0.56	0.54	0.63	
Drivers	0.85	0.88*	0.78*	0.78	0.51	0.47	
Loaders	0.01	0.00	0.53	0.61	0.99*	0.99	
Vehicle Lic. & Insurance	0.27	0.08	0.34	0.23	0.01	0.01	
Depot Costs	0.92*	0.80	0.21	0.06	0.05	0.18	
Dept. Admin	0.28	0.11	0.58	0.62	0.04	0.39	

First Reduction Regressions on Rural Costs - R^2 Values Annual Cost Against Annual Tonneage per Round

Criteria	Backdoor Bin		Kerbside Bin		Backdoor Sack, Backdoor Skep & Kerbside Sack
	XY	LogX LogY	XY	LogX LogY	
Fuel	0.99*	0.99	0.32	0.13	
Maint. Labour	0.93*	0.88	0.62	0.77*	Insufficient rural cases to enable any independent analysis on these methods
Spares	0.92*	0.87	↓	↓	
Tyres	0.92*	0.87	↓	↓	
Supplies	0.35	0.16	0.16	0.40	
Driver	0.84①	0.71	0.01	0.00	
Loaders	0.81①	0.66	0.00	0.00	
Vehicle Lic. & Insurance	0.40	0.12	0.04	0.07	
Depot Costs	0.31	0.01	0.12	0.10	
Dept. Admin	0.16	0.21	0.03	0.00	

* R^2 values $\geqslant$ 0.70. Largest R^2 taken where both XY and logX logY $\geqslant$70.XY plot used in preference where both have some R^2 value.

① R^2 values $\geqslant$ 0.70 but due to small sample size were not significant at the 5% level

Kerbside Sack Annual Operating Cost/round 1st Reduction

	URBAN			RURAL
Km^2	301	161	296	1356
t/round/y	260	270	286	104
Fuel	615	160	177	327
Maintenance	697	261	121	↓
Spares	516	246	142	377
Tyres	142	68	39	53
Supplies	880	1105	462	1000
Driver	713	671	781	1011
Loaders	1373	1921	2211	2976
Veh. Lic. & Insurance	100*	83	96	216
Depot Costs	3	32	N/A	158
Dept. Admin	21	326	N/A	226

* Estimated Value

N/A Not avalable or not known

Kerbside Bin - Annual Operating Cost/Round - 1st Reduction

	URBAN		RURAL			
km^2	200	184	2214	581	713	1553
t/round/y	295	317	104	364	286	260
Fuel	231	225	375	814	892	172
Maintenance	315	482				
Spares	8	12	250	1121	1339	481
Tyres	44	67				
Supplies	232	75	63	98	200	199
Driver	589	864	863	798	1680	516
Loaders	1718(1)	2592	1726	1489(1)	3251(1)	1033
Vehicle Licence and Insurance	85	24	98	100(2)	464	92
Depot costs	315	700	536	122	783	7
Dept. Admin.	395	1287	474	533	857	119

(1) Number of loaders adjusted

(2) Estimated value

Backdoor Skep - Annual Operating Cost/Round - 1st Reduction

	URBAN	
Km^2	59.1	54.3
t/round/y	213	206
Fuel	287	N/A
Maintenance)) Spares)	844	N/A
Tyres	67	N/A
Supplies	99	N/A
Driver	572	676
Loaders	1890	2502(1)
Vehicle Licence and Insurance	182	99
Depot costs	84	N/A
Dept. Admin.	379	229

(1) Number of loaders adjusted

Backdoor Bin - Annual Operating Cost/Round - 1st Reduction

	URBAN					RURAL		
km^2	111	79	36.9	47.4	301	966	2221	606
t/round/y	260	224	260	208	250	390	185	246
Fuel	208	121	192	347	159	362	222	263
Maintenance	184	201	700	530	177	341	149	153
Spares	118	86	36	227	79	182	80	81
Tyres	35	52	12	90	79	113	62	62
Supplies	43	76	300	102	N/A	218	163	79
Driver	661	989	826	1434	N/A	1579	711	589
Loaders	2268	3724	2814	2166(1)	N/A	4222	2037 (1)	1611
Vehicle Licence and Insurance	170	108	106	172	110	148	90	16
Depot costs	310	12	286	26	N/A	66	278	0
Dept. Admin.	0	62	500	N/A	N/A	86	140	363

(1) Number of loaders adjusted

N/A Not available

Backdoor Sack - Annual Operating Cost/Round - 1st Reduction

	URBAN					RURAL	
km^2	180	948	285	173	94	1325	1433
t/round/y	302	150	312	250	250	230	104
Fuel	400	205	342	194	448	194	505
Maintenance						619	276
Spares	1196	501	1395	152	705	485	217
Tyres	156	136	182	50	92	338	151
Supplies	1259	863	1692	1056	880	778	1550
Driver	1310	650	1183	778	1060	354	1930
Loaders	4855(1)	2600	3550	3120	4000	1062	5419
Vehicle Licence and Insurance	340	133	219	111	90(2)	92	50
Depot costs	394	392	1119	112	300(2)	248	0
Dept. Admin.	669	188	450	208	355	315	210

(1) Number of loaders adjusted

(2) Estimated value

APPENDIX 7D

Collection

Second Reduction Costs and Corresponding R^2 Values

Notation:

x_{Km} : Area of authority (Km^2)

x_{try} : tonne/round/year

x_{rwv} : rounds/week/vehicle

x_{nrw} : total number of rounds/week

x_{ncv} : total number of collection vehicles (for all collection operations not just domestic rounds)

Second Reduction Regressions on Urban Costs - R^2 Values Annual Cost Against Annual Cost Against Area of Authority (Km^2)

Criteria	Kerbside Sack		Backdoor Sack		Backdoor Bin		Kerbside Bin and Backdoor Skep
	XY	LogX LogY	XY	LogX LogY	XY	LogX LogY	
Fuel	E		E		E		Insufficient urban cases to enable any independent analyses of these methods
Maint. Labour	E		E		E		
Spares	E		E		E		
Tyres	E		E		E		
Supplies	E		E		/		
Drivers	E		E		E		Kerbside bin where necessary Bk bin values are used
Loaders	E		E		E		
Vehicle Lic. & Insurance	E		E		E		
Depot Costs	0.90	0.83	0.91	0.83	0.88	0.70	Bk skep where necessary Bk sack values are used
Dept. Admin	0.89	0.89	0.98	0.94	0.96	0.95	
Total Op. Cost (excl. capital charges	0.89	0.89	0.98	0.94	0.96	0.95	

Second Reduction Regressions on Rural Costs - R^2 Values Annual Cost Against Area of Authority (Km^2)

Criteria	Kerbside Bin		Backdoor Bin		Backdoor Sack, Backdoor Skep & Kerbside Sack
	XY	LogX LogY	XY	LogX LogY	
Fuel	E			E	Insufficient rural cases to enable any independent analyses of these methods
Maint. Labour	E			E	
Spares	E			E	
Tyres	E			E	
Supplies	E			E	
Drivers	E			E	
Loaders	E			E	
Vehicle Lic. & Insurance	E			E	
Depot Costs	0.66	0.75	Urban	Backdoor bin	
Dept. Admin	0.86	0.81	0.99	0.99	
Total Op. Cost (excl. capital charges	0.86	0.81	0.99	0.99	

E = Cost relationship derived empirically
Bk = Backdoor

Kerbside Sack Annual Operating Cost/round 2nd Reduction

	URBAN			RURAL
x_{Km} x_{try} x_{rwv} x_{nrw} x_{ncv}	301 260 9.8 132 22	161 270 9.5 69 10	296 286 10 100 12	1356 104 10 40 8
Fuel	364	195	358	325
Maintenance	412	221	392	380
Spares	307	164	302	
Tyres	84	45	83	54
Supplies	662	687	728	1000
Driver	750	750	750	750
Loaders	2070	2070	2070	1380
Veh. Lic. & Insurance	120	120	120	120
Depot Costs	836	593	525	150
Dept. Admin	837	723	795	651
Total Op. Cost (excl. Cap. charges	6442	5568	6123	4910

Kerbside Bin - Annual Operating Cost/Round - 2nd Reduction

	URBAN		RURAL			
x_{km}	184	200	2214	581	713	1553
x_{try}	317	295	104	364	286	260
x_{rwv}	10	10	10	10	10	10
x_{nrw}	221	95	105	90	105	70
x_{ncv}	34	17	14	16	17	12
Fuel	219	238	310	81	100	217
Maintenance	464	504	443	116	143	311
Spares	11	12				
Tyres	64	70				
Supplies	100	100	140	140	140	140
Driver	750	750	750	750	750	750
Loaders	2070	2070	1380	1380	1380	1380
Vehicle Licence and Insurance	120	120	120	120	120	120
Depot costs	242	278	61	202	277	28
Dept. Admin.	602	617	477	415	433	438
Total Op. cost (excluding capital charges)	4642	4759	3681	3204	3343	3384

Backdoor Skep - Annual Operating Cost/Round - 2nd Reduction

	URBAN	
x_{km}	59.1	54.3
x_{try}	213	206
x_{rwv}	10	10
x_{nrw}	180	180
x_{ncv}	29	43
Fuel	99	91
Maintenance Spares	156	143
Tyres	21	19
Supplies	100	100
Driver	750	750
Loaders	2760	2760
Vehicle Licence and Insurance	120	120
Depot costs	253	376
Dept. Admin.	651	666
Total Op. cost (excluding capital charges)	4892	5007

Backdoor Bin - Annual Operating Cost/Round - 2nd Reduction

	URBAN					RURAL		
X_{km}	111	79	36.9	47.4	301	966	2221	606
X_{try}	260	224	260	208	250	390	185	246
X_{rwv}	10	10	10	10	10	10	9.25	10
X_{nrw}	360	60	140	290	250	80	111	65
X_{ncv}	67	17	16	32	60	16	14	15
Fuel	145	103	48	62	394	319	733	200
Maintenance	132	94	44	56	358	290	666	182
Spares	57	40	19	24	154	155	355	97
Tyres	39	28	13	17	105	87	200	55
Supplies	100	100	100	100	100	150	150	150
Driver	750	750	750	750	750	750	750	750
oaders	2760	2760	2760	2760	2760	2070	2070	2070
Vehicle Licence and Insurance	120	120	120	120	120	120	120	120
Depot costs	294	440	177	173	474	187	48	140
Dept. Admin.	662	667	607	611	784	620	764	565
Total Op. cost (excluding capital charges)	5059	5102	4638	4673	5999	4748	5856	4329

Backdoor Sack - Annual Operating Cost/Round - 2nd Reduction

	URBAN					RURAL	
χ_{km}	180	94.8	285	173	94	1325	1433
χ_{try}	302	150	312	250	250	230	104
χ_{rwv}	10	10	10	10	10	10	10
χ_{nrw}	150	80	60	160	100	75	20
χ_{ncv}	21	16	10	41	14	7	5
Fuel	302	159	479	291	158	331	358
Maintenance	475	250	752	457	248	265	287
Spares						212	229
Tyres	63	33	100	61	33	146	158
Supplies	809	402	836	670	670	1100	1100
Driver	750	750	750	750	750	750	750
Loaders	2760	2760	2760	2760	2760	2070	2070
Vehicle Licence and Insurance	120	120	120	120	120	120	120
Depot costs	213	378	469	244	296	150	150
Dept. Admin.	836	740	952	823	767	775	786
Total Op. cost (excluding capital charges)	6310	5574	7200	6210	5784	5919	6008

APPENDIX 7E

Collection:

Base Case Operating Costs and Percentage Values

Urban Authorities

URBAN - Backdoor Bin

```
OPERATING COSTS
AREA(KM2)      50.      75.     100.     125.     150.     175.     200.     225.     250.     275.     300.       0.       0.
*************************************************************************************************************************************

VEH.FUEL      65.5     98.2    131.0    163.8    196.5    229.2    262.0    294.8    327.5    360.2    393.0      0.0      0.0

V.MT.LAB      59.5     89.3    119.0    148.8    178.5    208.3    238.0    267.8    297.5    327.3    357.0      0.0      0.0

V.SPARES      25.5     38.3     51.0     63.8     76.5     89.3    102.0    114.8    127.5    140.3    153.0      0.0      0.0

V.TYRES       17.5     26.3     35.0     43.8     52.5     61.3     70.0     78.8     87.5     96.3    105.0      0.0      0.0

LICENCES     120.0    120.0    120.0    120.0    120.0    120.0    120.0    120.0    120.0    120.0    120.0      0.0      0.0

DRIVER       750.0    750.0    750.0    750.0    750.0    750.0    750.0    750.0    750.0    750.0    750.0      0.0      0.0

LOADERS     2760.0   2760.0   2760.0   2760.0   2760.0   2760.0   2760.0   2760.0   2760.0   2760.0   2760.0      0.0      0.0

SUPPLIES     100.0    100.0    100.0    100.0    100.0    100.0    100.0    100.0    100.0    100.0    100.0      0.0      0.0

DEPOT        311.5    311.5    311.5    311.5    311.5    311.5    311.5    311.5    311.5    311.5    311.5      0.0      0.0

ADMIN        623.5    639.8    656.0    672.3    688.5    704.8    721.0    737.3    753.5    769.8    786.0      0.0      0.0

*************************************************************************************************************************************

SUM.TOTAL   4833.0   4933.2   5033.5   5133.7   5234.0   5334.2   5434.5   5534.7   5635.0   5735.2   5635.5      0.0      0.0
(EXCLUDING CAPITAL CHARGES)


CP.CHARGE    873.9    873.9    873.9    873.9    873.9    873.9    873.9    873.9    873.9    873.9    673.9      0.0      0.0
*************************************************************************************************************************************

SUM.TOTAL   5706.8   5807.1   5907.3   6007.6   6107.8   6208.1   6308.3   6408.6   6508.8   6609.1   6709.3      0.0      0.0
(INCLUDING CAPITAL CHARGES)
```

URBAN - Backdoor Bin

```
PERCENTAGE VALUES - [illegible] COSTS
(INCLUDING CAPITAL [illegible])

AREA(M*2)     50.    75.   100.   125.   150.   175.   200.   225.   250.   275.   300.     0.     0.
****************************************************************************************************

VEH.FUEL      1.1    1.7    2.2    2.7    3.2    3.7    4.2    4.6    5.0    5.5    5.9    0.0    0.0

V.MT.LAB      1.0    1.5    2.0    2.5    2.9    3.4    3.8    4.2    4.6    5.0    5.3    0.0    0.0

V.SPARES      0.4    0.7    0.9    1.1    1.3    1.4    1.6    1.8    2.0    2.1    2.3    0.0    0.0

V.TYRES       0.3    0.5    0.6    0.7    0.9    1.0    1.1    1.2    1.3    1.5    1.6    0.0    0.0

LICENCES      2.1    2.1    2.0    2.0    2.0    1.9    1.9    1.9    1.8    1.8    1.8    0.0    0.0

DRIVER       13.1   12.9   12.7   12.5   12.3   12.1   11.9   11.7   11.5   11.3   11.2    0.0    0.0

LOADERS      48.4   47.5   46.7   45.9   45.2   44.5   43.8   43.1   42.4   41.8   41.1    0.0    0.0

SUPPLIES      1.8    1.7    1.7    1.7    1.6    1.6    1.6    1.6    1.5    1.5    1.5    0.0    0.0

DEPOT         5.5    5.4    5.3    5.2    5.1    5.0    4.9    4.9    4.8    4.7    4.6    0.0    0.0

ADMIN        10.9   11.0   11.1   11.2   11.3   11.4   11.4   11.5   11.6   11.6   11.7    0.0    0.0

CP.CHARGE    15.3   15.0   14.8   14.5   14.3   14.1   13.9   13.6   13.4   13.2   13.0    0.0    0.0

****************************************************************************************************

SUB.TOTAL   100.0  100.0  100.0  100.0  100.0  100.0  100.0  100.0  100.0  100.0  100.0    0.0    0.0
```

URBAN - Backdoor Sack

```
OPERATING COSTS
AREA(KM2)      50.       75.      100.      125.      150.      175.      200.      225.      250.      275.      300.        0.        0.
****************************************************************************************************************************************************

VEH.FUEL      84.0     126.0     168.0     210.0     252.0     294.0     336.0     378.0     420.0     462.0     504.0       0.0       0.0

V.MT.LAB & SPARES
             132.0     198.0     264.0     330.0     396.0     462.0     528.0     594.0     660.0     726.0     792.0       0.0       0.0

V.TYRES       17.5      26.3      35.0      43.8      52.5      61.3      70.0      78.8      87.5      96.3     105.0       0.0       0.0

LICENCES     120.0     120.0     120.0     120.0     120.0     120.0     120.0     120.0     120.0     120.0     120.0       0.0       0.0

DRIVER       750.0     750.0     750.0     750.0     750.0     750.0     750.0     750.0     750.0     750.0     750.0       0.0       0.0

LOADERS     2760.0    2760.0    2760.0    2760.0    2760.0    2760.0    2760.0    2760.0    2760.0    2760.0    2760.0       0.0       0.0

SUPPLIES     668.5     668.5     668.5     668.5     668.5     668.5     668.5     668.5     668.5     668.5     668.5       0.0       0.0

DEPOT        316.5     316.5     316.5     316.5     316.5     316.5     316.5     316.5     316.5     316.5     316.5       0.0       0.0

ADMIN        704.5     730.3     756.0     781.8     807.5     833.3     859.0     884.8     910.5     936.3     962.0       0.0       0.0

****************************************************************************************************************************************************

SUM.TOTAL   5553.0    5695.5    5838.0    5980.5    6123.0    6265.5    6408.0    6550.5    6693.0    6835.5    6978.0       0.0       0.0
(EXCLUDING CAPITAL CHARGES)

CP.CHARGE    873.9     873.9     873.9     873.9     873.9     873.9     873.9     873.9     873.9     873.9     873.9       0.0       0.0

****************************************************************************************************************************************************

SUM.TOTAL   6426.9    6569.4    6711.9    6854.4    6996.9    7139.4    7281.9    7424.4    7566.9    7709.4    7851.9       0.0       0.0
(INCLUDING CAPITAL CHARGES)
```

PERCENTAGE VALUES - OPERATING COSTS
(INCLUDING CAPITAL CHARGES)

URBAN - Backdoor Sack

AREA(KM2)	50.	75.	100.	125.	150.	175.	200.	225.	250.	275.	300.	0.	0.
VEH.FUEL	1.3	1.9	2.5	3.1	3.6	4.1	4.6	5.1	5.6	6.0	6.4	0.0	0.0
V.MT.LAB & SPARES	2.1	3.0	3.9	4.8	5.7	6.5	7.3	8.0	8.7	9.4	10.1	0.0	0.0
V.TYRES	0.3	0.4	0.5	0.6	0.8	0.9	1.0	1.1	1.2	1.2	1.3	0.0	0.0
LICENCES	1.9	1.6	1.8	1.8	1.7	1.7	1.6	1.6	1.6	1.6	1.5	0.0	0.0
DRIVER	11.7	11.4	11.2	10.9	10.7	10.5	10.3	10.1	9.9	9.7	9.6	0.0	0.0
LOADERS	42.9	42.0	41.1	40.3	39.4	38.7	37.9	37.2	36.5	35.8	35.2	0.0	0.0
SUPPLIES	10.4	10.2	10.0	9.8	9.6	9.4	9.2	9.0	8.8	8.7	8.5	0.0	0.0
DEPOT	4.9	4.8	4.7	4.6	4.5	4.4	4.3	4.3	4.2	4.1	4.0	0.0	0.0
ADMIN	11.0	11.1	11.3	11.4	11.5	11.7	11.8	11.9	12.0	12.1	12.3	0.0	0.0
CP.CHARGE	13.6	13.3	13.0	12.7	12.5	12.2	12.0	11.8	11.5	11.3	11.1	0.0	0.0
SUM.TOTAL	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	0.0	0.0

OPERATING COSTS

URBAN - Backdoor Skep

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AREA(KM2)      50.      75.     100.     125.     150.       0.       0.       0.       0.       0.       0.       0.       0.
****************************************************************************************************************************************

VEH.FUEL      84.0    126.0    168.0    210.0    252.0      0.0      0.0      0.0      0.0      0.0      0.0      0.0      0.0

V.MT.LAB & SPARES
             132.0    198.0    264.0    330.6    396.0      0.0      0.0      0.0      0.0      0.0      0.0      0.0      0.0

V.TYRES       17.5     26.3     35.0     43.8     52.5      0.0      0.0      0.0      0.0      0.0      0.0      0.0      0.0

LICENCES     120.0    120.0    120.0    120.0    120.0      0.0      0.0      0.0      0.0      0.0      0.0      0.0      0.0

DRIVER       750.0    750.0    750.0    750.0    750.0      0.0      0.0      0.0      0.0      0.0      0.0      0.0      0.0

LOADERS     2760.0   2760.0   2760.0   2760.0   2760.0      0.0      0.0      0.0      0.0      0.0      0.0      0.0      0.0

SUPPLIES     100.0    100.0    100.0    100.0    100.0      0.0      0.0      0.0      0.0      0.0      0.0      0.0      0.0

DEPOT        311.5    311.5    311.5    311.5    311.5      0.0      0.0      0.0      0.0      0.0      0.0      0.0      0.0

ADMIN        641.2    658.8    676.3    693.8    711.3      0.0      0.0      0.0      0.0      0.0      0.0      0.0      0.0

****************************************************************************************************************************************

SUM.TOTAL   4916.2   5050.5   5184.8   5319.0   5453.3      0.0      0.0      0.0      0.0      0.0      0.0      0.0      0.0
(EXCLUDING CAPITAL CHARGES)

CP.CHARGE    873.9    873.9    873.9    873.9    873.9      0.0      0.0      0.0      0.0      0.0      0.0      0.0      0.0

****************************************************************************************************************************************

SUM.TOTAL   5790.1   5924.3   6058.6   6192.9   6327.1      0.0      0.0      0.0      0.0      0.0      0.0      0.0      0.0
(INCLUDING CAPITAL CHARGES)
```

URBAN - Backdoor Skep

```
 PERCENTAGE VALUES - OPERATING COSTS
(INCLUDING CAPITAL CHARGES)

AREA(KM2)      50.      75.      100.     125.     150.      0.       0.       0.       0.       0.       0.       0.       0.
*****************************************************************************************************************************

VEH.FUEL        1.5      2.1      2.8      3.4      4.0      0.0      0.0      0.0      0.0      0.0      0.0      0.0      0.0

V.MT.LAB & SPARES
                2.3      3.3      4.4      5.3      6.3      0.0      0.0      0.0      0.0      0.0      0.0      0.0      0.0

V.TYRES         0.3      0.4      0.6      0.7      0.8      0.0      0.0      0.0      0.0      0.0      0.0      0.0      0.0

LICENCES        2.1      2.0      2.0      1.9      1.9      0.0      0.0      0.0      0.0      0.0      0.0      0.0      0.0

DRIVER         13.0     12.7     12.4     12.1     11.9      0.0      0.0      0.0      0.0      0.0      0.0      0.0      0.0

LOADERS        47.7     46.6     45.6     44.6     43.6      0.0      0.0      0.0      0.0      0.0      0.0      0.0      0.0

SUPPLIES        1.7      1.7      1.7      1.6      1.6      0.0      0.0      0.0      0.0      0.0      0.0      0.0      0.0

DEPOT           5.4      5.3      5.1      5.0      4.9      0.0      0.0      0.0      0.0      0.0      0.0      0.0      0.0

ADMIN          11.1     11.1     11.2     11.2     11.2      0.0      0.0      0.0      0.0      0.0      0.0      0.0      0.0


CP.CHARGE      15.1     14.8     14.4     14.1     13.8      0.0      0.0      0.0      0.0      0.0      0.0      0.0      0.0

*****************************************************************************************************************************

SUM.TOTAL     100.0    100.0    100.0    100.0    100.0      0.0      0.0      0.0      0.0      0.0      0.0      0.0      0.0
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URBAN - Kerbside Bin

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OPERATING COSTS

AREA(KM2)      50.      75.     100.     125.     150.     175.     200.     225.     250.     275.     300.       0.       0.
**************************************************************************************************************************

VEH.FUEL      59.5     89.3    119.0    148.8    178.5    208.3    238.0    267.8    297.5    327.3    357.0      0.0      0.0

V.MT.LAB     126.0    189.0    252.0    315.0    378.0    441.0    504.0    567.0    630.0    693.0    756.0      0.0      0.0

V.SPARES       3.0      4.5      6.0      7.5      9.0     10.5     12.0     13.5     15.0     16.5     18.0      0.0      0.0

V.TYRES       17.5     26.3     35.0     43.8     52.5     61.3     70.0     78.8     87.5     96.3    105.0      0.0      0.0

LICENCES     120.0    120.0    120.0    120.0    120.0    120.0    120.0    120.0    120.0    120.0    120.0      0.0      0.0

DRIVER       750.0    750.0    750.0    750.0    750.0    750.0    750.0    750.0    750.0    750.0    750.0      0.0      0.0

LOADERS     2070.0   2070.0   2070.0   2070.0   2070.0   2070.0   2070.0   2070.0   2070.0   2070.0   2070.0      0.0      0.0

SUPPLIES     100.0    100.0    100.0    100.0    100.0    100.0    100.0    100.0    100.0    100.0    100.0      0.0      0.0

DEPOT        311.5    311.5    311.5    311.5    311.5    311.5    311.5    311.5    311.5    311.5    311.5      0.0      0.0

ADMIN        533.6    549.1    564.5    580.0    595.4    610.9    626.3    641.8    657.2    672.7    688.1      0.0      0.0

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SUM.TOTAL   4091.1   4209.6   4328.0   4446.5   4564.9   4683.4   4801.8   4920.3   5038.7   5157.2   5275.6      0.0      0.0
(EXCLUDING CAPITAL CHARGES)


CP.CHARGE    873.9    873.9    873.9    873.9    873.9    873.9    873.9    873.9    873.9    873.9    873.9      0.0      0.0

**************************************************************************************************************************

SUM.TOTAL   4965.0   5083.4   5201.9   5320.3   5438.8   5557.2   5675.7   5794.1   5912.6   6031.0   6149.5      0.0      0.0
(INCLUDING CAPITAL CHARGES)
```

URBAN - Kerbside Bin

```
PERCENTAGE VALUES - OPERATING COSTS
(INCLUDING CAPITAL CHARGES)
AREA(KM2)      50.     75.    100.    125.    150.    175.    200.    225.    250.    275.    300.     0.      0.
*******************************************************************************************************************

VEH.FUEL       1.2     1.8     2.3     2.8     3.3     3.7     4.2     4.6     5.0     5.4     5.8     0.0     0.0

V.MT.LAB       2.5     3.7     4.8     5.9     7.0     7.9     8.9     9.8    10.7    11.5    12.3     0.0     0.0

V.SPARES       0.1     0.1     0.1     0.1     0.2     0.2     0.2     0.2     0.3     0.3     0.3     0.0     0.0

V.TYRES        0.4     0.5     0.7     0.8     1.0     1.1     1.2     1.4     1.5     1.6     1.7     0.0     0.0

LICENCES       2.4     2.4     2.3     2.3     2.2     2.2     2.1     2.1     2.0     2.0     2.0     0.0     0.0

DRIVER        15.1    14.8    14.4    14.1    13.8    13.5    13.2    12.9    12.7    12.4    12.2     0.0     0.0

LOADERS       41.7    40.7    39.8    38.9    38.1    37.2    36.5    35.7    35.0    34.3    33.7     0.0     0.0

SUPPLIES       2.0     2.0     1.9     1.9     1.8     1.8     1.8     1.7     1.7     1.7     1.6     0.0     0.0

DEPOT          6.3     6.1     6.0     5.9     5.7     5.6     5.5     5.4     5.3     5.2     5.1     0.0     0.0

ADMIN         10.7    10.8    10.9    10.9    10.9    11.0    11.0    11.1    11.1    11.2    11.2     0.0     0.0


CP.CHARGE     17.6    17.2    16.8    16.4    16.1    15.7    15.4    15.1    14.8    14.5    14.2     0.0     0.0
*******************************************************************************************************************

SUM.TOTAL    100.0   100.0   100.0   100.0   100.0   100.0   100.0   100.0   100.0   100.0   100.0     0.0     0.0
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URBAN - Kerbside Sack

```
OPERATING COSTS

AREA(KM2)      50.      75.     100.     125.     150.     175.     200.     225.     250.     275.     300.       0.       0.
**************************************************************************************************************************

VEH.FUEL      60.5     90.8    121.0    151.3    181.5    211.8    242.0    272.3    302.5    332.8    363.0      0.0      0.0

V.MT.LAB      68.5    102.8    137.0    171.3    205.5    239.8    274.0    308.3    342.5    376.8    411.0      0.0      0.0

V.SPARES      51.0     76.5    102.0    127.5    153.0    178.5    204.0    229.5    255.0    280.5    306.0      0.0      0.0

V.TYRES       14.0     21.0     28.0     35.0     42.0     49.0     56.0     63.0     70.0     77.0     84.0      0.0      0.0

LICENCES     120.0    120.0    120.0    120.0    120.0    120.0    120.0    120.0    120.0    120.0    120.0      0.0      0.0

DRIVER       750.0    750.0    750.0    750.0    750.0    750.0    750.0    750.0    750.0    750.0    750.0      0.0      0.0

LOADERS     2070.0   2070.0   2070.0   2070.0   2070.0   2070.0   2070.0   2070.0   2070.0   2070.0   2070.0      0.0      0.0

SUPPLIES     636.3    636.3    636.3    636.3    636.3    636.3    636.3    636.3    636.3    636.3    636.3      0.0      0.0

DEPOT        300.0    300.0    300.0    300.0    300.0    300.0    300.0    300.0    300.0    300.0    300.0      0.0      0.0

ADMIN        646.0    663.0    680.0    697.0    714.0    731.0    748.0    765.0    782.0    799.0    816.0      0.0      0.0

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SUM.TOTAL   4716.3   4830.3   4944.3   5058.3   5172.3   5286.3   5400.3   5514.3   5628.3   5742.3   5856.3      0.0      0.0
(EXCLUDING CAPITAL CHARGES)

CP.CHARGE    873.9    873.9    873.9    873.9    873.9    873.9    873.9    873.9    873.9    873.9    873.9      0.0      0.0

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SUM.TOTAL   5590.1   5704.1   5818.1   5932.1   6046.1   6160.1   6274.1   6388.1   6502.1   6616.1   6730.1      0.0      0.0
(INCLUDING CAPITAL CHARGES)
```

URBAN - Kerbside Sack

```
PERCENTAGE VALUES - OPERATING COSTS
(INCLUDING CAPITAL CHARGES)

AREA(KM2)     50.     75.    100.    125.    150.    175.    200.    225.    250.    275.    300.      0.      0.
*******************************************************************************************************************

VEH.FUEL      1.1     1.6     2.1     2.5     3.0     3.4     3.9     4.3     4.7     5.0     5.4     0.0     0.0

V.MT.LAB.     1.2     1.8     2.4     2.9     3.4     3.9     4.4     4.8     5.3     5.7     6.1     0.0     0.0

V.SPARES      0.9     1.3     1.8     2.1     2.5     2.9     3.3     3.6     3.9     4.2     4.5     0.0     0.0

V.TYRES       0.3     0.4     0.5     0.6     0.7     0.8     0.9     1.0     1.1     1.2     1.2     0.0     0.0

LICENCES      2.1     2.1     2.1     2.0     2.0     1.9     1.9     1.9     1.8     1.8     1.8     0.0     0.0

DRIVER       13.4    13.1    12.9    12.6    12.4    12.2    12.0    11.7    11.5    11.3    11.1     0.0     0.0

LOADERS      37.0    36.3    35.6    34.9    34.2    33.6    33.0    32.4    31.8    31.3    30.8     0.0     0.0

SUPPLIES     11.4    11.2    10.9    10.7    10.5    10.3    10.1    10.0     9.8     9.6     9.5     0.0     0.0

DEPOT         5.4     5.3     5.2     5.1     5.0     4.9     4.8     4.7     4.6     4.5     4.5     0.0     0.0

ADMIN        11.6    11.6    11.7    11.7    11.8    11.9    11.9    12.0    12.0    12.1    12.1     0.0     0.0


CP.CHARGE    15.6    15.3    15.0    14.7    14.5    14.2    13.9    13.7    13.4    13.2    13.0     0.0     0.0

*******************************************************************************************************************

SUM.TOTAL   100.0   100.0   100.0   100.0   100.0   100.0   100.0   100.0   100.0   100.0   100.0     0.0     0.0
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Rural Authorities

RURAL - Backdoor Bin

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OPERATING COSTS
AREA(KM2)      500.     750.    1000.    1250.    1500.    1750.    2000.      0.       0.       0.       0.       0.       0.
*******************************************************************************************************************************

VEH.FUEL      165.0    247.5    330.0    412.5    495.0    577.5    660.0     0.0      0.0      0.0      0.0      0.0      0.0

V.MT.LAB      150.0    225.0    300.0    375.0    450.0    525.0    600.0     0.0      0.0      0.0      0.0      0.0      0.0

V.SPARES       80.0    120.0    160.0    200.0    240.0    280.0    320.0     0.0      0.0      0.0      0.0      0.0      0.0

V.TYRES        45.0     67.5     90.0    112.5    135.0    157.5    180.0     0.0      0.0      0.0      0.0      0.0      0.0

LICENCES      120.0    120.0    120.0    120.0    120.0    120.0    120.0     0.0      0.0      0.0      0.0      0.0      0.0

DRIVER        750.0    750.0    750.0    750.0    750.0    750.0    750.0     0.0      0.0      0.0      0.0      0.0      0.0

LOADERS      2070.0   2070.0   2070.0   2070.0   2070.0   2070.0   2070.0     0.0      0.0      0.0      0.0      0.0      0.0

SUPPLIES      150.0    150.0    150.0    150.0    150.0    150.0    150.0     0.0      0.0      0.0      0.0      0.0      0.0

DEPOT         110.0    110.0    110.0    110.0    110.0    110.0    110.0     0.0      0.0      0.0      0.0      0.0      0.0

ADMIN         557.0    587.0    617.0    647.0    677.0    707.0    737.0     0.0      0.0      0.0      0.0      0.0      0.0

*******************************************************************************************************************************

SUM.TOTAL    4197.0   4447.0   4697.0   4947.0   5197.0   5447.0   5697.0     0.0      0.0      0.0      0.0      0.0      0.0
(EXCLUDING CAPITAL CHARGES)

CP.CHARGE     873.9    873.9    873.9    873.9    873.9    873.9    873.9     0.0      0.0      0.0      0.0      0.0      0.0

*******************************************************************************************************************************

SUM.TOTAL    5070.8   5320.8   5570.8   5820.8   6070.8   6320.8   6570.8     0.0      0.0      0.0      0.0      0.0      0.0
(INCLUDING CAPITAL CHARGES)
```

RURAL - Backdoor Bin

```
PERCENTAGE VALUES - OPERATING COSTS
(INCLUDING CAPITAL CHARGES)
AREA(KM2)      500.    750.   1000.   1250.   1500.   1750.   2000.     0.      0.      0.      0.      0.      0.
**************************************************************************************************************
VEH.FUEL       3.3     4.7     5.9     7.1     8.2     9.1    10.0     0.0     0.0     0.0     0.0     0.0     0.0

V.MT.LAB       3.0     4.2     5.4     6.4     7.4     8.3     9.1     0.0     0.0     0.0     0.0     0.0     0.0

V.SPARES       1.6     2.5     2.9     3.4     4.0     4.4     4.9     0.0     0.0     0.0     0.0     0.0     0.0

V.TYRES        0.9     1.3     1.6     1.9     2.2     2.5     2.7     0.0     0.0     0.0     0.0     0.0     0.0

LICENCES       2.4     2.3     2.2     2.1     2.0     1.9     1.8     0.0     0.0     0.0     0.0     0.0     0.0

DRIVER        14.8    14.1    13.5    12.9    12.4    11.9    11.4     0.0     0.0     0.0     0.0     0.0     0.0

LOADERS       40.8    38.9    37.2    35.6    34.1    32.7    31.5     0.0     0.0     0.0     0.0     0.0     0.0

SUPPLIES       3.0     2.8     2.7     2.6     2.5     2.4     2.3     0.0     0.0     0.0     0.0     0.0     0.0

DEPOT          2.2     2.1     2.0     1.9     1.8     1.7     1.7     0.0     0.0     0.0     0.0     0.0     0.0

ADMIN         11.0    11.0    11.1    11.1    11.2    11.2    11.2     0.0     0.0     0.0     0.0     0.0     0.0


CP.CHARGE     17.2    16.4    15.7    15.0    14.4    13.8    13.3     0.0     0.0     0.0     0.0     0.0     0.0
**************************************************************************************************************

SUM.TOTAL    100.0   100.0   100.0   100.0   100.0   100.0   100.0     0.0     0.0     0.0     0.0     0.0     0.0
```

RURAL - Backdoor Sack

```
OPERATING COSTS

AREA(KM2)      500.     750.    1000.    1250.    1500.    1750.    2000.       0.       0.       0.       0.       0.       0.
***********************************************************************************************************************************

VEH.FUEL      125.0    187.5    250.0    312.5    375.0    437.5    500.0      0.0      0.0      0.0      0.0      0.0      0.0

V.MT.LAB      100.0    150.0    200.0    250.0    300.0    350.0    400.0      0.0      0.0      0.0      0.0      0.0      0.0

V.SPARES       80.0    120.0    160.0    200.0    240.0    280.0    320.0      0.0      0.0      0.0      0.0      0.0      0.0

V.TYRES        55.0     82.5    110.0    137.5    165.0    192.5    220.0      0.0      0.0      0.0      0.0      0.0      0.0

LICENCES      120.0    120.0    120.0    120.0    120.0    120.0    120.0      0.0      0.0      0.0      0.0      0.0      0.0

DRIVER        750.0    750.0    750.0    750.0    750.0    750.0    750.0      0.0      0.0      0.0      0.0      0.0      0.0

LOADERS      2070.0   2070.0   2070.0   2070.0   2070.0   2070.0   2070.0      0.0      0.0      0.0      0.0      0.0      0.0

SUPPLIES     1100.0   1100.0   1100.0   1100.0   1100.0   1100.0   1100.0      0.0      0.0      0.0      0.0      0.0      0.0

DEPOT         150.0    150.0    150.0    150.0    150.0    150.0    150.0      0.0      0.0      0.0      0.0      0.0      0.0

ADMIN         682.5    709.5    736.5    763.5    790.5    817.5    844.5      0.0      0.0      0.0      0.0      0.0      0.0

***********************************************************************************************************************************

SUM.TOTAL    5232.5   5439.5   5646.5   5853.5   6060.5   6267.5   6474.5      0.0      0.0      0.0      0.0      0.0      0.0
(EXCLUDING CAPITAL CHARGES)

CP.CHARGE     873.9    873.9    873.9    873.9    873.9    873.9    873.9      0.0      0.0      0.0      0.0      0.0      0.0
***********************************************************************************************************************************

SUM.TOTAL    6106.4   6313.4   6520.4   6727.4   6934.4   7141.4   7348.4      0.0      0.0      0.0      0.0      0.0      0.0
(INCLUDING CAPITAL CHARGES)
```

RURAL - Backdoor Sack

```
PERCENTAGE VALUES - OPERATING COSTS
(INCLUDING CAPITAL CHARGES)

AREA(KM2)      500.    750.   1000.   1250.   1500.   1750.   2000.     0.      0.      0.      0.      0.      0.
*******************************************************************************************************************

VEH.FUEL        2.0     3.0     3.8     4.6     5.4     6.1     6.8     0.0     0.0     0.0     0.0     0.0     0.0

V.MT.LAB        1.6     2.4     3.1     3.7     4.3     4.9     5.4     0.0     0.0     0.0     0.0     0.0     0.0

V.SPARES        1.3     1.9     2.5     3.0     3.5     3.9     4.4     0.0     0.0     0.0     0.0     0.0     0.0

V.TYRES         0.9     1.3     1.7     2.0     2.4     2.7     3.0     0.0     0.0     0.0     0.0     0.0     0.0

LICENCES        2.0     1.9     1.8     1.8     1.7     1.7     1.6     0.0     0.0     0.0     0.0     0.0     0.0

DRIVER         12.3    11.9    11.5    11.1    10.8    10.5    10.2     0.0     0.0     0.0     0.0     0.0     0.0

LOADERS        33.9    32.8    31.7    30.8    29.9    29.0    28.2     0.0     0.0     0.0     0.0     0.0     0.0

SUPPLIES       16.0    17.4    16.9    16.4    15.9    15.4    15.0     0.0     0.0     0.0     0.0     0.0     0.0

DEPOT           2.5     2.4     2.3     2.2     2.2     2.1     2.0     0.0     0.0     0.0     0.0     0.0     0.0

ADMIN          11.2    11.2    11.3    11.3    11.4    11.4    11.5     0.0     0.0     0.0     0.0     0.0     0.0


CP.CHARGE      14.3    13.8    13.4    13.0    12.6    12.2    11.9     0.0     0.0     0.0     0.0     0.0     0.0

*******************************************************************************************************************

SUM.TOTAL     100.0   100.0   100.0   100.0   100.0   100.0   100.0     0.0     0.0     0.0     0.0     0.0     0.0
```

RURAL - Kerbside Bin

```
OPERATING COSTS

AREA(KM2)       500.     750.    1000.    1250.    1500.    1750.    2000.      0.       0.       0.       0.       0.       0.
********************************************************************************************************************************

VEH.FUEL        70.0    105.0    140.0    175.0    210.0    245.0    280.0     0.0      0.0      0.0      0.0      0.0      0.0

V.MT.LAB, SPARES & TYRES
               100.0    150.0    200.0    250.0    300.0    350.0    400.0     0.0      0.0      0.0      0.0      0.0      0.0

LICENCES       120.0    120.0    120.0    120.0    120.0    120.0    120.0     0.0      0.0      0.0      0.0      0.0      0.0

DRIVER         750.0    750.0    750.0    750.0    750.0    750.0    750.0     0.0      0.0      0.0      0.0      0.0      0.0

LOADERS       1380.0   1380.0   1380.0   1380.0   1380.0   1380.0   1380.0     0.0      0.0      0.0      0.0      0.0      0.0

SUPPLIES       140.0    140.0    140.0    140.0    140.0    140.0    140.0     0.0      0.0      0.0      0.0      0.0      0.0

DEPOT          110.0    110.0    110.0    110.0    110.0    110.0    110.0     0.0      0.0      0.0      0.0      0.0      0.0

ADMIN          416.0    423.5    431.0    438.5    446.0    453.5    461.0     0.0      0.0      0.0      0.0      0.0      0.0
********************************************************************************************************************************

SUM.TOTAL     3086.0   3178.5   3271.0   3363.5   3456.0   3548.5   3641.0     0.0      0.0      0.0      0.0      0.0      0.0
(EXCLUDING CAPITAL CHARGES)


CP.CHARGE      873.9    873.9    873.9    873.9    873.9    873.9    873.9     0.0      0.0      0.0      0.0      0.0      0.0
********************************************************************************************************************************

SUM.TOTAL     3959.8   4052.3   4144.8   4237.3   4329.8   4422.3   4514.8     0.0      0.0      0.0      0.0      0.0      0.0
(INCLUDING CAPITAL CHARGES)
```

```
 PERCENTAGE VALUES - OPERATING COSTS                                  RURAL - Kerbside Bin
(INCLUDING CAPITAL CHARGES)

AREA(KM2)      500.      750.      1000.     1250.     1500.     1750.     2000.        0.        0.        0.        0.        0.        0.
*********************************************************************************************************************************************

VEH.FUEL          1.8       2.6       3.4       4.1       4.9       5.5       6.2       0.0       0.0       0.0       0.0       0.0       0.0

V.MT.LAB, SPARES & TYRES
                  2.5       3.7       4.6       5.9       6.9       7.9       8.9       0.0       0.0       0.0       0.0       0.0       0.0

LICENCES          3.0       3.0       2.9       2.8       2.8       2.7       2.7       0.0       0.0       0.0       0.0       0.0       0.0

DRIVER           18.9      18.5      18.1      17.7      17.3      17.0      16.6       0.0       0.0       0.0       0.0       0.0       0.0

LOADERS          34.8      34.1      33.3      32.6      31.9      31.2      30.6       0.0       0.0       0.0       0.0       0.0       0.0

SUPPLIES          3.5       3.5       3.4       3.3       3.2       3.2       3.1       0.0       0.0       0.0       0.0       0.0       0.0

DEPOT             2.8       2.7       2.7       2.6       2.5       2.5       2.4       0.0       0.0       0.0       0.0       0.0       0.0

ADMIN            10.5      10.5      10.4      10.3      10.3      10.3      10.2       0.0       0.0       0.0       0.0       0.0       0.0

CP.CHARGE        22.1      21.6      21.1      20.6      20.2      19.8      19.4       0.0       0.0       0.0       0.0       0.0       0.0

*********************************************************************************************************************************************

SUM.TOTAL       100.0     100.0     100.0     100.0     100.0     100.0     100.0       0.0       0.0       0.0       0.0       0.0       0.0
```

RURAL - Kerbside Sack

```
OPERATING COSTS

AREA(KM2)       500.     750.    1000.    1250.    1500.    1750.    2000.       0.       0.       0.       0.       0.       0.
*****************************************************************************************************************************

VEH.FUEL       120.0    180.0    240.0    300.0    360.0    420.0    480.0      0.0      0.0      0.0      0.0      0.0      0.0

V.MT.LAB & SPARES
               140.0    210.0    280.0    350.0    420.0    490.0    560.0      0.0      0.0      0.0      0.0      0.0      0.0

V.TYRES         20.0     30.0     40.0     50.0     60.0     70.0     80.0      0.0      0.0      0.0      0.0      0.0      0.0

LICENCES       120.0    120.0    120.0    120.0    120.0    120.0    120.0      0.0      0.0      0.0      0.0      0.0      0.0

DRIVER         750.0    750.0    750.0    750.0    750.0    750.0    750.0      0.0      0.0      0.0      0.0      0.0      0.0

LOADERS       1380.0   1380.0   1380.0   1380.0   1380.0   1380.0   1380.0      0.0      0.0      0.0      0.0      0.0      0.0

SUPPLIES      1000.0   1000.0   1000.0   1000.0   1000.0   1000.0   1000.0      0.0      0.0      0.0      0.0      0.0      0.0

DEPOT          150.0    150.0    150.0    150.0    150.0    150.0    150.0      0.0      0.0      0.0      0.0      0.0      0.0

ADMIN          552.0    573.0    594.0    615.0    636.0    657.0    678.0      0.0      0.0      0.0      0.0      0.0      0.0

*****************************************************************************************************************************

SUM.TOTAL     4232.0   4393.0   4554.0   4715.0   4876.0   5037.0   5198.0      0.0      0.0      0.0      0.0      0.0      0.0
(EXCLUDING CAPITAL CHARGES)


CP.CHARGE      873.9    873.9    873.9    873.9    873.9    873.9    873.9      0.0      0.0      0.0      0.0      0.0      0.0
*****************************************************************************************************************************

SUM.TOTAL     5105.9   5266.9   5427.9   5588.9   5749.9   5910.9   6071.9      0.0      0.0      0.0      0.0      0.0      0.0
(INCLUDING CAPITAL CHARGES)
```

RURAL - Kerbside Sack

```
PERCENTAGE VALUES - OPERATING COSTS
(INCLUDING CAPITAL CHARGES)

AREA(KM2)      500.     750.    1000.    1250.    1500.    1750.    2000.       0.       0.       0.       0.       0.       0.
**************************************************************************************************************************************

VEH.FUEL        2.4      3.4      4.4      5.4      6.3      7.1      7.9      0.0      0.0      0.0      0.0      0.0      0.0

V.MT.LAB & SPARES
                2.7      4.0      5.2      6.3      7.3      8.3      9.2      0.0      0.0      0.0      0.0      0.0      0.0

V.TYRES         0.4      0.6      0.7      0.9      1.0      1.2      1.3      0.0      0.0      0.0      0.0      0.0      0.0

LICENCES        2.4      2.3      2.2      2.1      2.1      2.0      2.0      0.0      0.0      0.0      0.0      0.0      0.0

DRIVER         14.7     14.2     13.8     13.4     13.0     12.7     12.4      0.0      0.0      0.0      0.0      0.0      0.0

LOADERS        27.0     26.2     25.4     24.7     24.0     23.3     22.7      0.0      0.0      0.0      0.0      0.0      0.0

SUPPLIES       19.6     19.0     18.4     17.9     17.4     16.9     16.5      0.0      0.0      0.0      0.0      0.0      0.0

DEPOT           2.9      2.8      2.8      2.7      2.6      2.5      2.5      0.0      0.0      0.0      0.0      0.0      0.0

ADMIN          10.8     10.9     10.9     11.0     11.1     11.1     11.2      0.0      0.0      0.0      0.0      0.0      0.0


CP.CHARGE      17.1     16.6     16.1     15.6     15.2     14.8     14.4      0.0      0.0      0.0      0.0      0.0      0.0

**************************************************************************************************************************************

SUM.TOTAL     100.0    100.0    100.0    100.0    100.0    100.0    100.0      0.0      0.0      0.0      0.0      0.0      0.0
```

APPENDIX 7F

Collection:

Relative Sensitivities for Base Case Operating Costs

Urban Authorities

URBAN - Backdoor Bin

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RELATIVE SENSITIVITIES (RS) - OPERATING COSTS
*********************************************

SENSITIVITY RANGES CONSIDERED
  X OR / 2.00 : FUEL
  X OR / 1.50 : VEHICLE MAINT LABOUR, DRIVER, LOADERS,ADMIN, DEPOT COSTS, CAPITAL CHARGES
  X OR / 1.25 : VEHICLE SPARES + TYRES, VEH.INSURANCE & LICENCES, SUPPLIES

                                      RS VALUES
SEE COMMENT IN CAPITAL COST SECTION


AREA(KM2)       50.      75.      100.     125.     150.     175.     200.     225.     250.     275.     300.      0.       0.
*************************************************************************************************************************************

VEH.FUEL      0.011    0.017    0.022    0.027    0.032    0.037    0.041    0.046    0.050    0.054    0.058    0.000    0.000

V.MT.LAB      0.010    0.015    0.020    0.025    0.029    0.033    0.038    0.042    0.045    0.049    0.053    0.000    0.000

V.SPARES      0.004    0.007    0.009    0.011    0.013    0.014    0.016    0.018    0.020    0.021    0.023    0.000    0.000

V.TYRES       0.003    0.005    0.006    0.007    0.009    0.010    0.011    0.012    0.013    0.015    0.016    0.000    0.000

LICENCES      0.021    0.021    0.020    0.020    0.020    0.019    0.019    0.019    0.018    0.018    0.018    0.000    0.000

DRIVER        0.130    0.128    0.125    0.123    0.121    0.119    0.117    0.116    0.114    0.112    0.111    0.000    0.000

LOADERS       0.461    0.454    0.446    0.439    0.432    0.426    0.419    0.413    0.407    0.401    0.395    0.000    0.000

SUPPLIES.     0.017    0.017    0.017    0.017    0.016    0.016    0.016    0.016    0.015    0.015    0.015    0.000    0.000

 DEPOT        0.054    0.053    0.052    0.052    0.051    0.050    0.049    0.048    0.048    0.047    0.046    0.000    0.000

ADMIN         0.108    0.109    0.110    0.111    0.111    0.112    0.113    0.114    0.114    0.115    0.116    0.000    0.000

CP.CHARGE     0.151    0.148    0.146    0.143    0.141    0.139    0.137    0.135    0.132    0.130    0.129    0.000    0.000
```

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RELATIVE SENSITIVITIES (RS) - OPERATING COSTS
*********************************************

SENSITIVITY RANGES CONSIDERED
  X OR / 2.00 : FUEL
  X OR / 1.50 : VEHICLE MAINT LABOUR, DRIVER, LOADERS,ADMIN, DEPOT COSTS, CAPITAL CHARGES
  X OR / 1.25 : VEHICLE SPARES + TYRES, VEH.INSURANCE & LICENCES, SUPPLIES

                                          RS VALUES
SEE COMMENT IN CAPITAL COST SECTION

AREA(KM2)      50.     75.    100.    125.    150.    175.    200.    225.    250.    275.    300.      0.      0.
********************************************************************************************************************

VEH.FUEL     0.013   0.019   0.025   0.031   0.036   0.041   0.046   0.051   0.055   0.060   0.064   0.000   0.000

V.MT.LAB & SPARES
             0.020   0.030   0.039   0.048   0.056   0.064   0.072   0.079   0.086   0.093   0.100   0.000   0.000

V.TYRES      0.003   0.004   0.005   0.006   0.007   0.009   0.010   0.011   0.012   0.012   0.013   0.000   0.000

LICENCES     0.019   0.018   0.018   0.017   0.017   0.017   0.016   0.016   0.016   0.016   0.015   0.000   0.000

DRIVER       0.115   0.113   0.111   0.108   0.106   0.104   0.102   0.100   0.098   0.096   0.095   0.000   0.000

LOADERS      0.412   0.403   0.395   0.387   0.379   0.372   0.365   0.358   0.352   0.346   0.340   0.000   0.000

SUPPLIES     0.103   0.101   0.099   0.097   0.095   0.093   0.091   0.089   0.088   0.086   0.084   0.000   0.000

DEPOT        0.049   0.048   0.047   0.046   0.045   0.044   0.043   0.042   0.042   0.041   0.040   0.000   0.000

ADMIN        0.108   0.110   0.111   0.113   0.114   0.115   0.117   0.118   0.119   0.120   0.121   0.000   0.000

CP.CHARGE    0.134   0.131   0.129   0.126   0.123   0.121   0.119   0.116   0.114   0.112   0.110   0.000   0.000
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URBAN - Backdoor Skep

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RELATIVE SENSITIVITIES (RS) - OPERATING COSTS
*********************************************

SENSITIVITY RANGES CONSIDERED
  X OP / 2.00 : FUEL
  X OP / 1.50 : VEHICLE MAINT LABOUR, DRIVER, LOADERS,ADMIN, DEPOT COSTS, CAPITAL CHARGES
  X OP / 1.25 : VEHICLE SPARES & TYRES, VEH.INSURANCE & LICENCES, SUPPLIES

                                       RS VALUES
SEE COMMENT IN CAPITAL COST SECTION

AREA(KM2)     50.     75.    100.    125.    150.      0.      0.      0.      0.      0.      0.      0.      0.
*****************************************************************************************************************

VEH.FUEL     0.014   0.021   0.028   0.034   0.040   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000

V.MT.LAB & SPARES
             0.023   0.033   0.043   0.053   0.062   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000

V.TYRES      0.003   0.004   0.006   0.007   0.008   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000

LICENCES     0.021   0.020   0.020   0.019   0.019   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000

DRIVER       0.128   0.125   0.122   0.120   0.117   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000

LOADERS      0.455   0.445   0.436   0.427   0.419   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000

SUPPLIES     0.017   0.017   0.016   0.016   0.016   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000

DEPOT        0.054   0.052   0.051   0.050   0.049   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000

ADMIN        0.110   0.110   0.110   0.111   0.111   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000

CP.CHARGE    0.149   0.145   0.142   0.139   0.136   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000
```

RELATIVE SENSITIVITIES (RS) - OPERATING COSTS   **URBAN - Kerbside Bin**

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*************************************************

SENSITIVITY RANGES CONSIDERED
  X OR / 2.00 : FUEL
  X OR / 1.50 : VEHICLE MAINT LABOUR, DRIVER, LOADERS,ADMIN, DEPOT COSTS, CAPITAL CHARGES
  X OR / 1.25 : VEHICLE SPARES & TYRES, VEH.INSURANCE & LICENCES, SUPPLIES

                                  RS VALUES

SEE COMMENT IN CAPITAL COST SECTION

AREA(KM2)    50.     75.     100.    125.    150.    175.    200.    225.    250.    275.    300.    0.      0.
*********************************************************************************************************************

VEH.FUEL     0.012   0.018   0.023   0.028   0.033   0.037   0.042   0.046   0.050   0.054   0.058   0.000   0.000

V.MT.LAB     0.025   0.037   0.048   0.059   0.069   0.079   0.088   0.097   0.105   0.114   0.121   0.000   0.000

V.SPARES     0.001   0.001   0.001   0.001   0.002   0.002   0.002   0.002   0.003   0.003   0.003   0.000   0.000

V.TYRES      0.004   0.005   0.007   0.008   0.010   0.011   0.012   0.014   0.015   0.016   0.017   0.000   0.000

LICENCES     0.024   0.024   0.023   0.023   0.022   0.022   0.021   0.021   0.020   0.020   0.019   0.000   0.000

DRIVER       0.149   0.145   0.142   0.139   0.136   0.133   0.130   0.128   0.125   0.123   0.120   0.000   0.000

LOADERS      0.400   0.391   0.383   0.375   0.367   0.359   0.352   0.345   0.338   0.332   0.326   0.000   0.000

SUPPLIES     0.020   0.020   0.019   0.019   0.018   0.018   0.018   0.017   0.017   0.017   0.016   0.000   0.000

DEPOT        0.062   0.061   0.060   0.058   0.057   0.056   0.055   0.053   0.052   0.051   0.050   0.000   0.000

ADMIN        0.106   0.107   0.107   0.108   0.109   0.109   0.109   0.110   0.110   0.110   0.111   0.000   0.000

CP.CHARGE    0.173   0.169   0.165   0.162   0.158   0.155   0.152   0.149   0.146   0.143   0.140   0.000   0.000
```

URBAN - Kerbside Sack

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RELATIVE SENSITIVITIES (RS) - OPERATING COSTS
*********************************************

SENSITIVITY RANGES CONSIDERED
  X OR / 2.00 : FUEL
  X OR / 1.50 : VEHICLE MAINT LABOUR, DRIVER, LOADERS,ADMIN, DEPOT COSTS, CAPITAL CHARGES
  X OR / 1.25 : VEHICLE SPARES & TYRES, VEH.INSURANCE & LICENCES, SUPPLIES

                                          RS VALUES
SEE COMMENT 1: CAPITAL COST SECTION


AREA(KM2)      50.      75.     100.     125.     150.     175.     200.     225.     250.     275.     300.       0.       0.
*****************************************************************************************************************************

VEH.FUEL      0.011    0.016    0.021    0.025    0.030    0.034    0.038    0.042    0.046    0.050    0.054    0.000    0.000

V.MT.LAB      0.012    0.018    0.023    0.029    0.034    0.039    0.043    0.048    0.052    0.057    0.061    0.000    0.000

V.SPARES      0.009    0.013    0.018    0.021    0.025    0.029    0.032    0.036    0.039    0.042    0.045    0.000    0.000

V.TYRES       0.003    0.004    0.005    0.006    0.007    0.008    0.009    0.010    0.011    0.012    0.012    0.000    0.000

LICENCES      0.021    0.021    0.021    0.020    0.020    0.019    0.019    0.019    0.018    0.018    0.018    0.000    0.000

DRIVER        0.132    0.130    0.127    0.125    0.123    0.120    0.118    0.116    0.114    0.112    0.110    0.000    0.000

LOADERS       0.357    0.350    0.344    0.337    0.331    0.325    0.319    0.314    0.309    0.303    0.298    0.000    0.000

SUPPLIES      0.113    0.110    0.108    0.106    0.104    0.102    0.100    0.099    0.097    0.095    0.094    0.000    0.000

DEPOT         0.053    0.052    0.051    0.050    0.049    0.048    0.048    0.047    0.046    0.045    0.044    0.000    0.000

ADMIN         0.114    0.115    0.116    0.116    0.117    0.117    0.118    0.118    0.119    0.119    0.120    0.000    0.000

CP.CHARGE     0.154    0.151    0.148    0.145    0.142    0.140    0.137    0.135    0.133    0.130    0.128    0.000    0.000
```

Rural Authorities

RURAL - Backdoor Bin

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RELATIVE SENSITIVITIES (RS) - OPERATING COSTS
**********************************************

SENSITIVITY RANGES CONSIDERED
  X OR / 2.00 : FUEL
  X OR / 1.50 : VEHICLE MAINT LABOUR, DRIVER, LOADERS,ADMIN, DEPOT COSTS, CAPITAL CHARGES
  X OR / 1.25 : VEHICLE SPARES & TYRES, VEH.INSURANCE & LICENCES, SUPPLIES

                                                RS VALUES
SEE COMMENT IN CAPITAL COST SECTION

AREA(KM2)    500.     750.    1000.    1250.    1500.    1750.    2000.      0.       0.       0.       0.       0.       0.
************************************************************************************************************************************

VEH.FUEL    0.032    0.046    0.059    0.070    0.081    0.091    0.099    0.000    0.000    0.000    0.000    0.000    0.000

V.MT.LAB    0.029    0.042    0.054    0.064    0.074    0.082    0.090    0.000    0.000    0.000    0.000    0.000    0.000

V.SPARES    0.016    0.023    0.029    0.034    0.039    0.044    0.048    0.000    0.000    0.000    0.000    0.000    0.000

V.TYRES     0.009    0.013    0.016    0.019    0.022    0.025    0.027    0.000    0.000    0.000    0.000    0.000    0.000

LICENCES    0.024    0.023    0.021    0.021    0.020    0.019    0.018    0.000    0.000    0.000    0.000    0.000    0.000

DRIVER      0.146    0.139    0.133    0.127    0.122    0.117    0.113    0.000    0.000    0.000    0.000    0.000    0.000

LOADERS     0.392    0.374    0.358    0.343    0.330    0.317    0.305    0.000    0.000    0.000    0.000    0.000    0.000

SUPPLIES    0.029    0.028    0.027    0.026    0.025    0.024    0.023    0.000    0.000    0.000    0.000    0.000    0.000

DEPOT       0.022    0.021    0.020    0.019    0.018    0.017    0.017    0.000    0.000    0.000    0.000    0.000    0.000

ADMIN       0.109    0.109    0.110    0.110    0.110    0.111    0.111    0.000    0.000    0.000    0.000    0.000    0.000

CP.CHARGE   0.169    0.162    0.154    0.148    0.142    0.136    0.131    0.000    0.000    0.000    0.000    0.000    0.000
```

RURAL - Backdoor Sack

```
RELATIVE SENSITIVITIES (RS) - OPERATING COSTS
*************************************************

SENSITIVITY RANGES CONSIDERED
  X OR / 2.00 : FUEL
  X OR / 1.50 : VEHICLE MAINT LABOUR, DRIVER, LOADERS,ADMIN, DEPOT COSTS, CAPITAL CHARGES
  X OR / 1.25 : VEHICLE SPARES & TYRES, VEH.INSURANCE & LICENCES, SUPPLIES

                                                    RS VALUES
SEE COMMENT IN CAPITAL COST SECTION

AREA(KM2)      500.     750.    1000.    1250.    1500.    1750.    2000.       0.       0.       0.       0.       0.       0.
*****************************************************************************************************************************************

VEH.FUEL      0.020    0.030    0.038    0.046    0.054    0.061    0.068    0.000    0.000    0.000    0.000    0.000    0.000

V.MT.LAB      0.016    0.024    0.031    0.037    0.043    0.049    0.054    0.000    0.000    0.000    0.000    0.000    0.000

V.SPARES      0.013    0.019    0.024    0.030    0.034    0.039    0.043    0.000    0.000    0.000    0.000    0.000    0.000

V.TYRES       0.009    0.013    0.017    0.020    0.024    0.027    0.030    0.000    0.000    0.000    0.000    0.000    0.000

LICENCES      0.020    0.019    0.018    0.018    0.017    0.017    0.016    0.000    0.000    0.000    0.000    0.000    0.000

DRIVER        0.121    0.117    0.114    0.110    0.107    0.104    0.101    0.000    0.000    0.000    0.000    0.000    0.000

LOADERS       0.328    0.317    0.308    0.299    0.290    0.282    0.274    0.000    0.000    0.000    0.000    0.000    0.000

SUPPLIES      0.177    0.171    0.166    0.161    0.156    0.152    0.147    0.000    0.000    0.000    0.000    0.000    0.000

DEPOT         0.025    0.024    0.023    0.022    0.022    0.021    0.020    0.000    0.000    0.000    0.000    0.000    0.000

ADMIN         0.111    0.111    0.112    0.112    0.113    0.113    0.114    0.000    0.000    0.000    0.000    0.000    0.000

CP.CHARGE     0.141    0.137    0.132    0.128    0.124    0.121    0.118    0.000    0.000    0.000    0.000    0.000    0.000
```

RURAL - Kerbside Bin

```
RELATIVE SENSITIVITIES (RS) - OPERATING COSTS
****************************************************

SENSITIVITY RANGES CONSIDERED
  X OR / 2.00 : FUEL
  X OR / 1.50 : VEHICLE MAINT LABOUR, DRIVER, LOADERS,ADMIN, DEPOT COSTS, CAPITAL CHARGES
  X OR / 1.25 : VEHICLE SPARES & TYRES, VEH.INSURANCE & LICENCES, SUPPLIES

                                                   RS VALUES
SEE COMMENT IN CAPITAL COST SECTION

AREA(KM2)      500.      750.     1000.     1250.     1500.     1750.     2000.        0.        0.        0.        0.        0.        0.
*******************************************************************************************************************************************

VEH.FUEL      0.018     0.026     0.034     0.041     0.048     0.055     0.062     0.000     0.000     0.000     0.000     0.000     0.000

V.MT.LAB, SPARES & TYRES
              0.025     0.037     0.048     0.059     0.069     0.079     0.088     0.000     0.000     0.000     0.000     0.000     0.000

LICENCES      0.030     0.030     0.029     0.028     0.028     0.027     0.027     0.000     0.000     0.000     0.000     0.000     0.000

DRIVER        0.186     0.182     0.178     0.174     0.170     0.167     0.163     0.000     0.000     0.000     0.000     0.000     0.000

LOADERS       0.337     0.329     0.322     0.315     0.309     0.303     0.297     0.000     0.000     0.000     0.000     0.000     0.000

SUPPLIES      0.035     0.034     0.034     0.033     0.032     0.032     0.031     0.000     0.000     0.000     0.000     0.000     0.000

DEPOT         0.028     0.027     0.026     0.026     0.025     0.025     0.024     0.000     0.000     0.000     0.000     0.000     0.000

ADMIN         0.104     0.103     0.103     0.102     0.102     0.102     0.101     0.000     0.000     0.000     0.000     0.000     0.000

CP.CHARGE     0.216     0.211     0.206     0.202     0.198     0.194     0.190     0.000     0.000     0.000     0.000     0.000     0.000
```

RURAL - Kerbside Sack

```
RELATIVE SENSITIVITIES (Rs) - OPERATING COSTS
*********************************************

SENSITIVITY RANGES CONSIDERED
   X OR / 2.00 : FUEL
   X OR / 1.50 : VEHICLE MAINT LABOUR, DRIVER, LOADERS,ADMIN, DEPOT COSTS, CAPITAL CHARGES
   X OR / 1.25 : VEHICLE SPARES & TYRES, VEH.INSURANCE & LICENCES, SUPPLIES

                                         Rs VALUES
SEE COMMENT IN CAPITAL COST SECTION


AREA(KM2)      500.     750.     1000.    1250.    1500.    1750.    2000.       0.       0.       0.       0.       0.       0.
*********************************************************************************************************************************

VEH.FUEL       0.023    0.034    0.044    0.053    0.062    0.071    0.078    0.000    0.000    0.000    0.000    0.000    0.000

V.MT.LAB & SPARES
               0.027    0.040    0.051    0.062    0.073    0.082    0.091    0.000    0.000    0.000    0.000    0.000    0.000

V.TYRES        0.004    0.006    0.007    0.009    0.010    0.012    0.013    0.000    0.000    0.000    0.000    0.000    0.000

LICENCES       0.023    0.023    0.022    0.021    0.021    0.020    0.020    0.000    0.000    0.000    0.000    0.000    0.000

DRIVER         0.145    0.140    0.136    0.132    0.129    0.125    0.122    0.000    0.000    0.000    0.000    0.000    0.000

LOADERS        0.263    0.255    0.248    0.241    0.234    0.228    0.222    0.000    0.000    0.000    0.000    0.000    0.000

SUPPLIES       0.192    0.186    0.181    0.176    0.171    0.166    0.162    0.000    0.000    0.000    0.000    0.000    0.000

DEPOT          0.029    0.028    0.028    0.027    0.026    0.025    0.025    0.000    0.000    0.000    0.000    0.000    0.000

ADMIN          0.107    0.108    0.108    0.109    0.109    0.110    0.110    0.000    0.000    0.000    0.000    0.000    0.000

CP.CHARGE      0.168    0.163    0.158    0.154    0.150    0.146    0.142    0.000    0.000    0.000    0.000    0.000    0.000
```

APPENDICES ACCOMPANYING CHAPTER 8

APPENDIX 8A

Transfer:

Original Data

Compaction Transfer without Storage Capital Costs - Original Data

	One Compactor			Two Compactors		
Criteria	t/d 20 t/hr 11	49 7	65 11	100 14	160 22	192 22
Land	7500	0	0	11000		0
Site Survey and Design	5000	0	N/A	25000		N/A
Compaction Equipment	35000	35000	N/A	60000		72000
Other Ancillary Equipment	N/A	7000	0	62000		30000
Buildings and Civils	20000	45000	108840	820000	267008	260000
Other Prep. Costs	N/A	N/A	N/A	*		N/A

* Included in Buildings and Civils Cost

Compaction Transfer without Storage Operating Costs - Original Data

	One Compactor							Two Compactors	
Criteria	t/d 20 t/hr 11	28 (5)	31 (7)	45 (7)	49 7	65 11	72 (11)	100 14	160 22
Compaction equip maintenance	2000	5396	835	146	1125	N/A	2250	4500	4500
Electricity	3000	3660	2500	N/A	3416	607	6466	5000	N/A
Manual Labour	7500	12324	5425	16724	24570	29700	14402	39000	21000
Supervisory Labour	0	0	0	0	0	N/A	0	12000	0
Materials	0	108	670	497	324	1636	216	0	2500
Services	0	180	240	96	120	560	240	0	
Building Maint.	1000	109	0	0	164	6300	218	4000	
Dept. Admin	0	N/A	490	N/A	108	N/A	N/A	N/A	5000
Site Rent	9500	3289	3035	2000	956	0	37565	N/A	
Site Rates	1000		3275	2000	898	3200		N/A	

( ) Assumed rated capacities

Baling Capital Costs - Original Data

	One Baler			Two Balers
Criteria	t/d 75 t/hr 23	160 30	200 30	300 70
Land	0	0	1400	104000
Site Survey and Design	20000	N/A	N/A	N/A
Baling Equip. (incl. Installation)	131040	185000	616670	900000
Ancillary Equip (incl. Installation)	118384	80000		
Buildings and Civils	178800	500000	N/A	1845000
Other Preparation Costs	N/A	N/A	2000	86000
Site Vehicles	1machine	1 machine	N/A	N/A

Baling Operating Costs - Original Data

	One Baler			
Criteria	t/d 75	76	160	320
Transfer and Treatment Maintenance	12460	28821	27000	21604
Site Vehicle: Fuel Maint. Labour Spares Tyres Lic. & Ins.	2000	6380	3300	4243
Electricity	7120	5655	13760	87641
Manual Labour	20160	62832	28000	86171
Supervisory Lab	7640		7000	
Materials	17300	237	400	27478
Baling Wire	**	*	*	***
Services	100	875	750	3086
Building Maint.	1000	N/A	150	*
Dept. Admin.	9592	4860	3750	N/A
Site Rent	N/A	2690	N/A	N/A
Site Rates	4800	6484	17000	132123

* Included in Transfer and Treatment Equipment Maintenance Cost

** Included in Materials Cost

*** Baler produces self-sustaining bales, baling wire not necessary

Dry Pulverisation Capital Costs - Original Data

	One Pulveriser			Two Pulverisers	
Criteria	t/d 16 t/hr 15	58 9	92 15	180 30	340 30
Land	0	N/A	N/A	N/A	N/A
Site Survey and Design	0	N/A	35000	110000	N/A
Pulverisation Equp. (incl. Installation)	31385	450000	259425	N/A	749000
Ancillary Equip. (incl. Installation)	0			N/A	
Buildings and Civils	*		157500	N/A	
Other Preparation Costs	N/A		N/A	N/A	
Site Vehicles	One machine	One machine	One machine	One machine	Two machines

* Included in pulveriser equipment cost

Dry Pulverisation Operating Cost - Original Data

	One Pulveriser				Two Pulverisers		
Criteria	t/d 16	58	92	92	130	340	600
Transfer and Treatment Equip Maintenance	3771	16800	21660	16927	24000	84000	56250
Site Vehicle:							
Fuel	3000	6000	10840	N/A	N/A	N/A	78750
Maint. Labour							
Spares							
Tyres							
Lic. & Ins.							
Electricity	4000	14000	20068	12200	20000	46000	67500
Manual Labour	10000	28000	55000	53625	77650	200000	98000
Supervisory Lab.							
Materials	N/A	100	1722	2365	N/A	18000	**
Services	N/A	N/A	1302	240	N/A	2100	**
Building Maint.	N/A	15000	354	*	N/A	*	**
Dept. Admin.	***	N/A	N/A	18552	26000	N/A	N/A
Site Rent	12000	N/A	N/A	N/A	0	N/A	N/A
Site Rates		28200	N/A	9470	41000	89000	**

* Included in Transfer and Treatment Equipment Maintenance Cost

** Included in Site Vehicle Running Costs

*** Included in Labour Costs

Wet Pulverisation Capital Costs - Original Data

	One Pulveriser				Two Pulverisers	
Criteria	t/d 20	58	68	70	184	600
	t/hr 5	10	10	10	20	37.5
Land	N/A	0	N/A	0	N/A	N/A
Site Survey and Design	N/A	89425	N/A	0	N/A	N/A
Pulverisation Equip. (incl. Installation)	N/A	135947*	75000	345000	N/A	
Ancillary Equip (incl. Installation)	2062	111879			415200	
Buildings and Civils	N/A	406422		500000		3000000
Other Preparation Costs	N/A	N/A		8000		
Site Vehicles	One machine	One machine	One machine	One machine	One machine	Two O/H cranes

* Reconditioned pulveriser

O/H Overhead

Wet Pulverisation Operating Costs - Original Data

	One Pulveriser					Two Pulverisers		
Criteria	t/d 20	40	58	68	70	70	125	184
Transfer and Treatment Equip Maintenance	2300	2500	N/A	5900	3450	9500	40310②	47112
Site Vehicle:								
Fuel	3808	2750	N/A	6000	N/A	2416	Uses	1131
Maint. Labour						1836	grab	14135
Spares						895	crane	
Tyres								625
Lic. & Ins.						0		0
Electricity	5862	1500	N/A	6500	6000	12346	15000	12000
Manual Labour	9585	22500	19500	32000	13085	30487	40000	189720④
Supervisory Lab.	6663				0			
Materials	364	N/A	1577	110	6195	1748	②	9319
Services	100	N/A	10450	4010	850	386	②	36493②
Building Maint.	300	500	2000	900	750	500	②	②
Dept. Admin.	833	N/A	N/A	N/A	1150	9100	N/A	29959
Site Rent	0	N/A	5000	14000	0	0	24870	N/A
Site Rates	6623	1584		7000	9860	9727①	N/A	562440③

① Excludes £10000 for insurance

② Aggregated values

③ Includes annual capital charges

④ Subsequently found to include landfilling labour costs

APPENDIX 8B

Transfer:

Descriptive Derivation of each First and Second Reduction Component Cost

8B.1 TRANSFER CAPITAL COSTS

The total capital cost of each transfer method was broken down into a set of component costs. Some of these are common to all methods, for example, site survey and design, and building and civil engineering costs, whereas others are specific to only one or more operations. The analyses performed on the original data are described in detail in this Appendix.

The original data is given in Appendix 8A, the first reduction values in Appendix 8C and the second reduction values in Appendix 8D. These should be consulted in conjunction with the discussion presented here.

8B.1.1 SITE SURVEY AND DESIGN COSTS

The survey and design costs quoted by consultants are usually related to the cost of the plant being considered. Consequently, larger transfer stations will involve larger survey and design expenditures than smaller operations. A fixed cost had been considered, but over the wide range of daily tonneages reviewed, this does not reflect the above observation.

Data was only available for a limited number of cases, consequently survey and design costs were calculated as a fixed proportion of the total capital cost (ie. 70%):

		%
wet pulverisation	(1 case)	12
dry pulverisation	(1 case)	8
Baling	(1 case)	4
Compaction without transfer	(2 cases)	7
		3
	Mean Value	6.8 say 7% (of the capital cost of plant)

This percentage has been used to calculate empirically the survey and design costs for all transfer methods in the base case. A comparison of percentages found in the literature for operations tentatively related to refuse transfer stations and direct landfill is given in Table 8B.1 and similarities exist between the literature and this

TABLE 8B.1: Site Survey and Design Costs

Chemical Engineering		Waste Processing			This Work	
Chilton (1949)	Haselbarth (1960)	Smith (1975)	Stuckenbruck (1977)	Schroeder (1978)	Wet Pulv., Dry Pulv., Baling, Compaction (w/o storage, Apron, Bunker)	Direct Landfill
10%	6-12%	6.5-8.0%	5%	7.5%	ALL 7%	10%

w/o = without storage

work. It should be noted that this item does not include the cost of studies at aborted sites or extensive borehole drilling for hydrogeological surveys.

8B.1.2 TRANSFER EQUIPMENT

Compaction Equipment

The "installed cost" of compactors was derived from local authorities and equipment manufacturers (Table 8B.2a). The first reduction indicated that the cost is linearly related to rated capacity (in t/hr) and this cost function was used subsequently. It should be noted that the relationship in daily tonneage is almost as good as that for rated capacity, however, it was considered more logical to use the latter.

Treatment Equipment

In a similar manner to compaction equipment, the installed cost of treatment equipment was also derived from local authorities and supplemented where necessary with information from manufacturers (Table 8B.2b). Comparison of the installed costs of the treatment equipment clearly exhibits wide variations between the methods. At any particular capacity, drum pulverisers are by far the most expensive, followed by balers and hammermills. However, all three methods are more expensive than compaction equipment.

Dry pulverisation and baling equipment costs are both more closely related to the rated capacity of the treatment equipment (in t/hr). In these methods, the refuse has only a short retention time in the machines and hence they are designed to cope with instantaneous throughputs. However, it was found for wet pulverisation that equipment costs gave good relationships with both daily tonneage and rated capacity. The R^2 value for daily tonneage being marginally higher (0.97 and 0.96 respectively). The choice of an appropriate cost function is arbitrary. Daily tonneage was selected due to the nature of the wet pulverisation process. This method is characterised by a long waste retention time (in the order of several hours) and thus the equipment is tailored to deal with daily inputs rather than hourly throughputs.

TABLE 8B.2a: Manufacturers' Installed Costs for Compaction Equipment

t/hr Criterion	5	7	11	11	15
Compaction Equip. (incl. installation)	17000	32350	36800	35000	44750

TABLE 8B.2b: Manufacturer's Installed Costs for Treatment Equipment

Treatment Method	Rated Capacity (t/hr)													
	5	9	10	15	20	23	25	30	35	40	45	50	55	60
Baling (wire)				138000 130000		131000			200000 200000	185000		325000*		374000
Dry Pulverisation	64000		71000	90000			147000	160000		222000		283000		274000
Wet Pulverisation	325000		525000		625000									

* Baler producing self-sustaining bales

N.B. Costs are quoted for 1 machine only

8B.1.3 ANCILLARY EQUIPMENT

This item includes control equipment, switchgear, safety equipment, and in the more recent larger plants, a weighbridge dust extraction and noise suppression equipment. These latter items are not included in the base case for small plants. A compaction transfer station usually requires less ancillary equipment than pulverisation or baling plants. Due to the small number of cases obtained, empirical values have had to be derived using the limited information available, i.e.

Ancillary equipment cost = nx(£15000), where n is the number of compactors

For baling and wet pulverisation, high R^2 values were obtained from the first reduction regressions which demonstrated a linear relationship with daily tonneage for baling, and rated capacity for wet pulverisation. Conversely, with dry pulverisation the ancillary equipment cost was found to be very variable and further information was subsequently gathered from equipment manufacturers. They suggest ancillary equipment cost is in the order of 60% of the pulveriser cost for small operations, and 30% for larger plants, the resulting ancillary equipment costs are given in Table 8B.3. Using this data, dry pulverisation was found to exhibit a curvilinear relationship with rated capacity.

8B.1.4 BUILDINGS AND CIVILS

It was initially considered that the building and civil engineering costs at a "transfer without storage" plant would be similar to that for "apron" and "bunker storage" methods. This was not found to be the case. A larger tipping area is required with apron storage and hence a larger building is needed to accommodate this, and with bunker storage, stronger load-bearing walls are required to support the overhead crane. Consequently, an additional 10% has been added to the buildings and civils cost for both "storage" methods.

In the first reduction regression, buildings costs were found to be linearly related to daily tonneage.

TABLE 8B.3: Pulverisation Ancillary Equipment Cost Calculations

Rated Capacity (t/hr)	Manufacturers' Installed Cost for pulverisation equipment	Ancillary Equipment cost as a percentage of pulverisation equipment cost	Resultant Ancillary equipment cost
5	64000		
9	71000	60	38400
15	90000		42600
25	147000	50	54000
30	160000		73500
40	222000	40	80000
50	283000		88800
60	274000	30	113200
			82200

Treatment

In similarity with compaction transfer, it was initially thought that the building and civil cost would be identical for each treatment transfer method. This again was not found to be the case. Regressions with the combined values of two or all three methods gave consistently lower R^2 values than those for each individual method. Hence, it was concluded that this cost is dissimilar between the treatment methods.

Wet and dry pulverisation both exhibited a linear relation with daily tonneage in the first reduction. A linear relationship with daily tonneage ($R^2 = 0.94$), was also found for baling in the second reduction and used in preference to the rated capacity function ($R^2 = 0.98$) since it was found the rated capacity relationship produced unreasonable estimates over certain portions of the range of plant sizes considered. For example, small rises in the tonneage handled which involved the use of slightly higher rated balers produced a doubling of the building costs. While some increase is expected, this magnitude was considered too large. The daily tonneage function gave intuitively more reasonable results and was therefore used subsequently.

8B.1.5 OTHER PREPARATION COSTS (Fencing and Stores)

Fencing

The area of each size of operation was calculated according to a formula described in the site rent operating cost section of this appendix. This area was used to determine the fencing component of this cost. The area was initially treated as a circle and from which the minimum perimeter (C) can be calculated. This was then increased by 50% to take into account square, moderately rectangular and irregular shaped sites. An approximate unit cost for fencing is £10/m.

Derivation of minimum perimeter length using:

$$\left.\begin{array}{l} \sqrt{\frac{A}{\pi}} = r \\ \text{and then:} \\ C' = 2\pi r \end{array}\right\} \equiv \quad C = 2\pi\left(\sqrt{\frac{A}{\pi}}\right)$$

Stores

This cost covers a similar range of items to those described in the landfill chapter (Appendix 9B). Due to the larger number of men and the more technical nature of a treatment operation, a fixed sum of £3,000 has been added to the fencing component. This is three times greater than that used for landfill sites.

A summary of perimeter lengths, fencing and stores costs are given in Table 8B.4. This empirical relationship was found to be curvilinearly-related to daily tonneage.

8B.1.6 SITE VEHICLES

This capital cost refers to the rubber-tyred loading shovel(s) required to move refuse from the reception hall floor onto feed conveyors or into loading hoppers. The size of the vehicle (and hence cost) will depend upon the daily throughput of refuse. Loading shovel costs were empirically derived from manufacturers' price lists (Table 8B.5), and an identical cost function has been used for both treatment transfer and compaction apron storage.

8B.1.7 SLAVE VEHICLES AND POST-COMPACTION HANDLING

After the compaction of the refuse into a bulk container, it is then attached to an articulated tractor unit or lifted onto the chassis of a lorry for transport to the landfill. However, the situation arises at larger transfer stations where containers during peak periods are filled at a faster rate than tractor units are available to move them. Consequently, several methods have been derived to overcome this problem.

Small transfer stations, approx < 50t/d	Tractor unit(s) can adequately cope with fluctuation in incoming refuse.
Intermediate operations, approx 50-300t/d	Passive systems are used, the cost of which are included in the compaction equipment capital cost; e.g. twin loading streams for empty containers

TABLE 8B.4: Summary of Perimeter Length Calculations and the Fencing and Stores Costs

	t/d 20	49	65	100	160	192
Area required (ha) m^2	0.64 6400	0.93 9300	1.04 10400	1.24 12400	1.51 15100	1.62 16200
Circular Perimeter (m)	284	342	362	395	436	451
+ 50% (m)	142	171	181	198	218	226
Total Perimeter Length (m)	426	513	543	593	654	677
Cost @ £10/m (£)	4260	5130	5430	5930	6540	6770
ADD Stores component (£)	3000	3000	3000	3000	3000	3000
Total other Prep. Costs (£)	7260	8130	8430	8930	9540	9770

TABLE 8B.5: Manufacturers' Prices for Site Vehicles over the Range 20-600t/d

Daily Tonneage	20 50	100	150 200	250	300 350	400 450	500 550 600
No. of Machines	1 Vehicle			2 Vehicles			
Site Vehicle Cost (£)	30000	40000	50000	60000	80000	100000	120000

	or several empty containers on a conveyor belt system, short-term storage hopper (pulverisation only).
Large operations, approx > 300t/d	In addition to twin-loading streams, the fluctuations in waste throughput are such that it is likely that a slave vehicle will be required. This vehicle works on-site shunting empty containers to the compactor and full ones to the trailer park to await an available tractor unit. It is considered that: 1 slave is required for operations handling between 300-450t/d 2 slaves are required for operations handling between 450-600t/d

8B.1.8 BUNKER CONSTRUCTION COSTS (BUNKER STORAGE)

A bunker is assumed to be large enough to hold one days compactor throughput, and in larger operations one bunker to each compactor has been costed. Bunker construction is expensive, involving excavation and facing of a relatively large void. The cost can escalate by at least 100% should piling or construction below the water table be necessary.

An approximate unit cost of £200000/100t capacity or part thereof has been obtained from a construction company and was used in subsequent analyses.

8B.1.9 OVERHEAD CRANE OR CONVEYOR FEED SYSTEM (BUNKER STORAGE)

Transfer of refuse from the storage bunker can be achieved by either an overhead crane with a grab attachment or a conveyor system extending up from the base of the bunker. The cost of either method is similar though overhead cranes are more popular in Britain. The crane usually employed is of an electric overhead type with floor control and a "safe working load" of about 3 tonnes.

One crane or conveyor system is required for each bunker. The installed cost for one of these feed systems is about £26000 (mean of three manufacturers' prices).

8B.2 TRANSFER OPERATING COSTS

8B.2.1 TRANSFER EQUIPMENT MAINTENANCE

Compaction Equipment Maintenance

Although the first reduction regressions gave low R^2 values, a plot of these costs against daily tonneage indicated that the value for 28t/d was an 'extraordinary' high cost and the 45t/d value was below the plotted trend. The regression was subsequently re-run excluding these points and found to be linearly related to daily tonneage.

Transfer and Treatment Equipment Maintenance

Baling gave low R^2 values in the first reduction regression whereas wet pulverisation produced a high value, however, the latter on closer evaluation produced unrealistic results for low throughput operations. Consequently, a more detailed analysis for both methods was undertaken in the second redution.

Baling:	76t/d value considered to be an overestimate and subsequently deleted. 160t/d value considered to be an underestimate and subsequentely deleted. A linear relationship with daily tonneage was established.
Wet Pulverisation:	125t/d value considered to be an overestimate and reduced to 15000 after receiving additional information 184t/d value considered to be an overestimate and reduced to 20000. A linear relationship with daily tonneage was established

For dry pulverisation, the first reduction costs closely fitted a curvilinear relationship and were left unaltered.

8B.2.2 ELECTRICITY

Compaction: In the second reduction, the 65t/d cost was considered to be an underestimate and excluded. An R^2 value of 0.66 was obtained for the curvilinear relationship and in the absence of additional information, this cost function was subsequently used.

Electricity consumption at a compaction transfer station is lower than for any of the treatment transfer methods of a similar size.

Baling: A high R^2 value was obtained when the 320t/d value (for self-sustaining balers) was excluded. There consequently appears to be a marked difference in electricity costs between small (wire tied) and large (self-sustaining) baler operations. A linear relationship with daily tonneage was obtained over the range 75-200t/d. bove 200t/d, only one case was available and hence it was not possible to derive a reliable cost function. By inspection, a cost function twice the 75-200t/d one has been assumed.

Wet Pulverisation: As with baling there appears by observation to be a striking difference between small and large operations. No reliable functions were obtained probably due to the small sample size and therefore a fixed value of £6000 was estimated for one-machine and £13000 for two. These figures were based on the limited information available.

Dry Pulverisation: The first reduction costs gave a linear relationship with daily tonneage over the entire range considered and this cost function was subsequently used.

8B.2.3 MANUAL LABOUR, DRIVER AND VEHICLE MAINTENACE LABOUR, CRANE OPERATOR AND CRANE MAINTENANCE LABOUR

Manning levels were determined from local authority operations (Table 8B.6). Each workman is calculated at the same hourly rate as landfill manual workers, ie. £3.30/hour. This includes the basic wage plus 70% on-costs, and it is equivalent to £6900 per annum.

Apron and bunker storage both employ additional operators, ie. mobile plant drivers and crane operators respectively. These men were

TABLE 8B.6: Manual Labour Manning Levels

Transfer Methods	Daily Tonneage 0 50 100 150 200 250 300 350 400 450 500 550 600							
Baling	☒	4	5	6	8	10	☒	
Dry Pulverisation	2	4	6	9	12	14	16	18
Wet Pulverisation	☒	2	3	4	5	6		
Compaction with Apron Storage	3	4	5	6				
Compaction with bunker Storage	3	4	6	7	8			
Compaction without Storage	2	3	4	5				

TABLE 8B.7: Supervisory Labour Manning Levels

Transfer Methods	Daily Tonneage 0 50 100 150 200 250 300 350 400 450 500 550 600			
Baling	☒	1	2	
Dry Pulverisation	1	2	3	
Wet Pulverisation	☒	1	2	
Compaction Transfer	0.5	0.6	0.75	1

costed at the same wage as collection vehicle drivers, ie. £7500/year (£3.60/hour) and in addition the storage methods also require vehicle and crane maintenance labour. These expenditures were estimated as a linear relationship for apron storage ranging from one-fifth to four-fifths of the number of drivers, and for bunker storage between half and one times.

8B.2.4 SUPERVISORY LABOUR

Supervisory manning levels are given in Table 8B.7. Each supervisor is costed at £4.30/hr which includes the nationally-agreed basic wage and 70% for on-costs.

Supervisory manning levels are far higher for the treatment methods than compaction transfer, probably reflecting the more technical nature of the equipment employed.

8B.2.5 MATERIALS

Compaction: A large variation in materials cost was observed in the original data. It is considered as a small expenditure which will vary with the tonneage handled. An identical unit value to that for landfill disposal (Appendix 9B) was used, 0.020£/t, and the same linear relationship taken to derive the second reduction annual costs.

Baling: In the first reduction regressions, the materials cost was found to be linearly related to daily tonneage, this relationship was subsequently used.

Dry Pulverisation: The first reduction gave low R^2 values and subsequent adjustments could not determine any acceptable cost function. In the absence of further information, the direct landfill materials cost function in Appendix 9B was used. This is a linear relationship with daily tonneage.

Wet Pulverisation: In the second reduction the 68t/d value was considered to be an underestimate and hence excluded. The subsequent regression was found to be curvilinearly-related to daily tonneage with a scale factor of 1.14, suggesting a moderate diseconomy of scale in this cost.

8B.2.6 SERVICES

Compaction: The services available at compaction transfer stations are identical to those on landfill sites. The first reduction gave low R^2 values. Facilities between the range 20 and 75t/d (i.e. those employing one compactor) gave a mean cost of £170/y, significant at the 5% level. This fixed value was subsequently used for all one-compactor operations. A value of £300/y approximately double the one - compactor figure, has been used to estimate two compactor operations and £450/y has been used for three compactors.

The services required by each treatment transfer method are very similar, though wet pulverisation by the nature of the process has a larger element for water changes. No details are available on the relative proportions of each element making up this cost. In the case of wet pulverisation, however, it is argued that any additional cost for water is offset by lower costs associated with staff amenities on the grounds that this method requires fewer staff.

Baling: The first reduction figures gave a linear cost function with daily tonneage.

Dry Pulverisation: The first reduction linear cost function gave an R^2 of 0.68; in the absence of additional information, the relationship was subsequently used

Wet Pulverisation: The first reduction regressions produced low R^2 values. Subsequent analysis found no acceptable relationship. Consequently, the dry pulverisation cost function was used. This arrangement is not considered to be entirely satisfactory.

8B.2.7 BUILDING MAINTENANCE

No relationship with tonneage was identified for any transfer method. Therefore, fixed values have been assumed dependent upon the number of compactors in operation. The values are greater than those for landfill sites since each transfer station has larger buildings and paved areas to maintain.

The following scale of costs is used for all transfer methods except wet pulverisation and is based on the direct landfill Appendix 9B.

t/d	£/y
10-100	400
100-200	700
200-300	1000
300-400	1300
400-500	1600
500-600	1800

Wet Pulverisation: The first reduction costs produced a linear relationship with daily tonneage. At higher tonneages ($>$150t/d) these building maintenance costs are up to 350% larger than those for the other two methods. The reasons for this are likely to be inaccuracies in the empirical relationships for baling and dry pulverisation.

8B.2.8 SITE RENT

Site rents were found to be very site-specific. However, one can reasonably expect the size of site required for a transfer station will increase as daily throughput rises. At plants with high trhoughputs more space is required for the larger number of vehicles to manoeuvre, and for additional compacting and ancillary equipment. Therefore, rents are reasonably expected to increase with size of operation.

Low R^2 values were obtained in the first reduction regressions due in part to the influence of historic leasing agreements at different sites and to regional variations in land values. The site rent cost was consequently empirically derived. As of mid-1981, the annual leasing cost for a "serviced site" ranged from £7400/ha to £2700/ha (details from three authorities) and a mean value of £4500/ha was taken from this range.

Apron and bunker storage are considered to have the same site area requirements as without storage and from observations of local authorities operations, these were estimated as:

Minimum	0.5ha	small compactor station	≃20t/d
	1.0ha		≃75t/d
	1.5ha		≃150t/d
	1.75ha		≃225t/d

The estimated areas gave the relationship; $y=0.188\ ,^{0.41}$. At each site the area required was multiplied by the mean cost per hectare, £4500, so as to empirically derive the second reduction site rent costs.

8B.2.9 SITE RATES

Site rates were empirically derived as a proportion of site rent in the second reduction and expressed in terms of the site's rateable value. A value of 15% of the site rent was used in landfill disposal, since there are sites containing very little development. Conversely, transfer stations are highly developed and their rateable value will be a larger proportion of the annual site rent. A value of 65% significant at the 10% level was derived from seven cases for which data was obtained.

8B.2.10 DEPARTMENTAL ADMINISTRATION

This cost is almost totally neglected from the individual operating costs of existing transfer stations. From a limited sample size a value of 10% of the total operating cost (excluding capital changes) has been used.

By definition, this cost will follow a similar relationship to that of the total operating cost function.

8B.2.11 MOBILE PLANT RUNNING COSTS

Fuel cost is assumed to be a measure of vehicle utilisation. The same relationships for fuel, maintenance labour, spares and tyres derived for landfill disposal (Appendix 9B) were used for apron storage. However, one fundamental difference exists between these two operations which employ essentially identical equipment; landfilling involves soft surface working and transfer involves firm-surface working.

It was found that total firm-surface running costs (using detailed figures from one authority) are 80% of those for soft-surface operations. A comparison of the component running costs suggests there are large savings in fuel and tyre costs with firm surface working, though partly offset by increased spares and maintenance costs (Table 8B.8). Vehicle running costs are based on the soft surface cost function from direct landfill modified for firm surface operations using the percentages in Table 8B.8. Plants handling up to 250t/d are assumed to employ one vehicle and those upto 600t/d, two.

8B.2.12 VEHICLE LICENCES AND INSURANCE

Evidence was only available for one case and in the absence of further information a fixed value of £150/y was used for each piece of mobile plant.

8B.2.13 SLAVE VEHICLE MAINTENANCE COST

Slave vehicles are usually incorporated in with bulk transport costs. However, these vehicles are considered to be an integral part of a transfer operation over 300t/d and hence their maintenance cost has been derived empirically from the literature.

The Department of Industry Working Party on Materials Handling Costs (DOI, 1976), suggested that "equipment running costs" (fuel, maintenance, spares, tyres, licences and insurance) for industrial trucks can be reasonably estimated as 15% per annum of vehicle capital cost. This value was used to estimate each slave vehicle's running costs at all sizes of operation.

Labour costs for slave vehicles are incorporated in the manual labour cost section.

8B.2.14 CRANE ELECTRICITY (BUNKER STORAGE)

Technical details including the electricity requirements for overhead cranes were obtained from a manufacturer's own studies. Cranes used in bunker storage operations involve "long lifts" (over 25m) and visually operate in two motions simultaneously, ie. lifting and

TABLE 8B.8: Comparison between the Running Costs of a Loading Shovel for Soft and Firm Surface Working

Criteria	Firm Surface	Soft Surface	Comments
	TOTAL		
Total Running Costs (£)	11321	13900	Firm surface 80% of soft surface
	BREAKDOWN OF COSTS		
			Δ % w.r.t. firm surface
Fuel	2124	2500	- 15%
Maintenance Lab.	4049	3900	+ 4%
Spares	1989	1800	+ 10%
Tyres	3159	5700	- 45%

TABLE 8B.9: Overhead Crane Electricity Consumption Calculations

	10t/d	50t/d	100t/d
For every hr:	20min at full load $50 \times \frac{2}{6} = 17$	30min at full load $50 \times \frac{3}{6} = 25$	40min at full load $50 \times \frac{4}{6} = 33$
	20min redistributing: Grab $15 \times \frac{2}{6} = 5$	20min redistributing Grab $15 \times \frac{2}{6} = 5$	20min redistributing Grab $15 \times \frac{2}{6} = 5$
	Hoist $25 \times \frac{2}{6} = 8$	Hoist $25 \times \frac{2}{6} = 8$	Hoist $25 \times \frac{2}{6} = 8$
	20min Idle 0	10min Idle 0	0min Idle -
Total Consumption (Kwh)	30	38	46
Kwh/y=Kwhx7hr/d x250d	52500	66500	80500
Annual Cost @ 0.043£/Kwh	2258	2860	3462

travelling. Four electric motors are required, one each for hoisting (25Kwh), forward and reverse travel (5Kwh) and applying pressure to the grab's hydraulic systems (15Kwh). In total, these four motors consume approximately 50Kwh when operated at full capacity. Even when the crane is not operating at full load, it does not necessarily stand idle, instead for part of the time it will be used to sort and redistribute refuse in the bunker.

Manufacturers recommend one crane to each bunker as the most practicable arrangement and for any one hour the proportion of the time carrying, redistributing or standing idle is reasonably constant for each size of operation. Therefore, crane electricity consumption has been estimated in accordance with the manufacturer's observations in Table 8B.9. This table outlines the cost calculations for one crane and is valid over the range 10-100t/d. Operations > 100t/d in the base case require two bunkers and cranes. The cost, for example, of a 150t/d operation is estimated as 2 x 75t/d operation, and for a 300t/d operation, 3 x 100t/d. Consequently, crane electricity cost is a step-wise cost function corresponding to the number of cranes employed.

8B.2.15 CRANE MAINTENANCE AND SPARES (BUNKER STORAGE)

The maintenance and spares costs for an overhead crane are commonly not costed separately but inextricably contained within the compactor maintenance cost. A value has consequently had to be derived empirically. The 1976 Department of Industry Working Party on Materials Handling Costs suggested a value of 2% per annum of the capital cost for crane maintenance. It also suggests that cranes were in general seriously underutilised. This is not necessarily a transfer station as was seen in Table 8B.9. This point was taken into account when using the Working Party's report to estimate this component cost:

25- 50t/d - 2% p.a. of capital cost
50-100t/d - 4% " " " "
> 150t/d - 6% " " " "

The higher percentages are based on increased utilisation and wear at plants with larger daily throughputs.

8B.2.16 BALING WIRE (WIRE-TIED BALERS)

This cost was separated from the "materials" cost as it is specific only to wire-tied balers. Data was only obtained for the Lindemann-type balers and four strands of wire are assumed for each bale. (This is the modal value of known Lindemann balers, which operate with 3, 4 and 5 strands/bale depending upon each local authority's choice.) Baling wire is costed here since plastic strapping, twine, and polythene wrapping are not in popular use in Britain.

Over the range 50-300t/d (the tonneage range applicable to wire-tied balers), the first reduction regression was found to be linearly related to daily tonneage.

APPENDIX 8C

Transfer

First Reduction Costs and Corresponding R^2 Values

Compaction Transfer without Storage First Reduction Regressions Capital Costs R^2 Values

Criteria	Daily Tonneage (20-200t/d)		Rated Capacity (5-22t/hr)	
	XY	LogX LogY	XY	LogX LogY
Compactor Equip.	0.85	0.72	0.86*	0.84
Buildings and Civils	0.96*	0.96	0.90	0.63
Other Ancillary equipment	**			
Other Prep. Costs	**			
Site Survey and Design	**			

* Largest R^2 value $\geqslant$ 0.70 and relationship used in subsequent analyses. XY relationship selected in preference to LogX LogY when both R^2 values are identical.

** Insufficient values for regression analyses

Compaction Transfer without Storage First Reduction Regressions Operating Costs - R^2 Values

Criteria	Daily Tonneage (20-160t/d)	
	XY	LogX LogY
Compactor Maint.	0.16	0.05
Electricity	0.33	0.07
Manual Labour	E	E
Supervisory Lab.	E	E
Materials	0.05	0.12
Services	0.54	0.30
Building Maint.	0.19	0.30
Dept. Admin	0.22	0.22
Site Rent	0.03	0.06
Site Rates	0.04	0.00

E Empirically derived

Treatment Transfer First Reduction Regressions. Capital Costs R^2 Values

CRITERIA	BALING				DRY PULVERISATION				WET PULVERISATION			
	Daily Tonneage (t/d)		Rated Capacity (t/hr)		t/d		t/hr		t/d		t/hr	
	XY	LogX LogY	XY	LogX LogY	XY	LogX LogY	XY	LogX LogY	XY	LogX LogY	XY	LogX LogY
Site Survey	1	1	1	1	1	1	1	1	1	1	1	1
Transfer and Treatment Equipment	0.85	0.80	0.99*	0.99	0.73	0.56	0.99*	0.98	0.97*	0.95	0.96	0.94
Ancillary Equipment	0.74*	0.51	0.58	0.46	0.07	0.18	0.50	0.62	0.78	0.57	0.85*	0.57
Buildings and Civils	0.94	0.91	0.98*	0.90	0.92*	0.56	0.80	0.46	0.99*	0.99	0.95	0.89
Other Prep. Costs	1	1	1	1	1	1	1	1	1	1	1	1
Site Vehicles	1	1	1	1	1	1	1	1	1	1	1	1

1 Insufficient values for regression analyses

* Largest R^2 value $\geqslant 0.70$ and relationship used in subsequent analyses. XY plot used where both this and LogX LogY plot have identical R^2 values. Several of these relationships were reviewed in greater detail in the Second Reduction.

Treatment Transfer First Reduction Regression. Operating Costs R^2 Values

CRITERIA	BALING				DRY PULVERISATION		WET PULVERISATION	
	Incl. 320t/d value		excl. 320t/d value					
	XY	LogX LogY	XY	LogX LogY	XY	LogX LogY	XY	LogX LogY
Transfer & Treatment Equip. Maintenance	0.11	0.01	0.02	0.05	0.63	0.92*	0.93*	0.81
Site Vehicle:								
Fuel	1	1	1	1	1	1	1	1
Maint. Labour	1	1	1	1	1	1	1	1
Spares	1	1	1	1	1	1	1	1
Tyres	1	1	1	1	1	1	1	1
Lic. & Ins.	1	1	1	1	1	1	1	1
Electricity	0.93	0.94	0.97*	0.93	0.98*	0.97	0.49	0.37
Manual Labour	E	E	E	E	E	E	E	E
Supervisory Labour	E	E	E	E	0.97*	0.67	E	E
Materials	0.74*	0.26	0.24	0.15	0.99*	0.82	0.71*	0.36
Baling wire	2	2	0.99*	0.99	-	-	-	-
Services	0.88*	0.61	0.14	0.21	0.68	0.45	0.83*	0.64
Building Maint.	0.32	0.03	1	1	0.12	0.02	0.71*	0.65
Dept. Admin	1	1	0.06	0.14	1	1	0.91*	0.71
Site Rent	1	1	1	1	1	1	0.61	0.33
Site Rates	0.93	0.96	0.99*	0.95	0.01	0.01	0.34	0.12

1 Insufficient values for regression analyses E Empirically derived

2 Includes both wire-tied and self-sustaining balers

* Largest R^2 value $\geq$ 0.70 and relationship used in subsequent analyses. XY plot used where both this and LogX LogY plot have identical R^2 values. Several of these relationships were reviewed in greater detail in the Second Reduction

Compaction Transfer without Storage Capital Costs - First Reduction

	One Compactor			Two Compactors		
Criteria	t/d 20	49	65	100	160	192
	t/hr 11	7	11	14	22	22
Land			Assumed	Leased		
Site Survey and Design	5000	0	0	25000		0
Compaction Equipment	35000	35000	0	60000		72000
Other Ancillary Equipment	0	7000	0	62000		30000
Buildings and Civils	20000	5000[1]	108840	820000	267008	260000
Other Prep. Costs	0	0	0	0		0

[1] Temporary building

Compaction Transfer without Storage Operating Costs - First Reduction

	One Compactor							Two Compactors	
Criteria	t/d 20 t/hr 11	28 5	31 7	45 7	49 7	65 11	72 11	100 14	160 22
Compaction equip. maint.	2000[1]	5396	835	146	1125	N/A	2250	4500	4500
Electricity	3000	3660	2500	5625	3416	607	6466	5000	6832[1]
Manual Labour[2]	13800	13800	13800	13800	13800	20700	20700	26500	26500
Supervisory [2] Labour	2683	2683	2683	2683	2683	4025	4025	5366	5366
Materials	250	108	670	497	324	1636	216	250	750[3]
Services	200	180	240	96	120	560	240	200	750[3]
Building Maint.	1000	109	100	100	164	6300	218	4000	1500[3]
Dept. Admin	1262	700	2254	570	1422	2368	1176	3248	2000[3]
Site Rent	9500	2000[3]	3035	2000	956	0	10000[3]	N/A	2000[3]
Site Rates	1000	1289[3]	3575	2000	898	3200	2000[3]	N/A	1000[3]

1 Estimated by Local Authority (Cunningham, 1972)

2 Empirically derived

3 Estimated from aggregated values

N/A Not available or not known

Baling Capital Costs - First Reduction

Criteria	One Baler			Two Balers
	t/d 75 t/hr 23	160 30	200 30	300 70
Land	← Assumed Leased →			
Site Survey and Design	20,000	N/A	N/A	N/A
Baling Equipment (inc. installation)	131,040	185,000	185,000 [1]	400,000 [1]
Ancillary Equipment (inc. installation)	118,384	80,000	400,000	500,000
Buildings and Civils	178,800	500,000	N/A	1,845,000
Other Preparation Costs	N/A	N/A	2,000	86,000
Site Vehicle	20,680	20,000	N/A	N/A

[1] Manufacturers' Prices

N/A Not Available

Baling Operating Costs - First Reduction

Criteria	One Baler			
	t/d 75	76	160	320
Transfer and Treatment Equipment Maintenance	12,460	19,071 [1]	7,500 [1]	20,000 [2]
Electricity	7,120	5,655	13,760	87,641
Manual Labour	27,500	27,500	34,500	68,640
Supervisory Labour	9,000	9,000	9,000	18,000
Materials	7,550	237	400	27,478
Baling Wire	9,750 [3]	9,750 [4]	19,500 [5]	-
Services	100	875	750	3,086
Building Maintenance	1,000	N/A	150	1,604
Dept. Admin.	3,750	4,860	3,750	N/A
Site Rates	4,800	6,484	17,000	132,123

Insufficient number of cases to undertake analysis on site vehicle running costs and site rents.

[1] Excluding baling wire costs

[2] Excluding building maintenance cost

[3] Based on published values of 0.52p/t for the 75 t/d operation (Wastes Management, January 1982).

[4] Estimated value based on costs for similar-sized operations.

[5] 2 x 75 t/d cost

N/A Not Available

Dry Pulverisation Capital Costs - First Reduction

Criteria	One Pulveriser			Two Pulverisers	
	t/d 16	58	92	180	340
	t/hr 15	9	15	30	30
Land	← Assumed Leased →				
Site Survey and Design	N/A	N/A	35,000	110,000	N/A
Pulverisation Equipment (inc. installation) [1]	90,000	71,000	90,000	160,000	160,000
Ancillary Equipment (inc. installation)	169,425 [2]	78,000	169,425	178,600 [2]	178,600
Buildings and Civils	200,000	300,550	157,500	N/A	1,000,000
Other Preparation Costs [3]	6,993	8,268	8,780	9,579	10,405
Site Vehicles [3]	30,000	30,000	40,000	50,000	80,000

[1] Values derived from manufacturers' prices.

[2] Based on similar-sized operations for which the cost was known.

[3] Where it has not been possible to evaluate certain cost criteria a corresponding relationship has been used from compaction transfer.

N/A Not Available.

Dry Pulverisation Operating Costs - First Reduction

Criteria	One Pulveriser				Two Pulverisers		
	t/d 16	58	92	92	130	340	600
Transfer and Treatment Equipment Maintenance	3,771	16,800	21,660	16,575	24,000	82,000	56,250
Electricity	4,000	14,000	20,068	12,200	20,000	46,000	67,500
Manual Labour	13,800	27,500	41,000	41,000	48,000	89,000	130,500
Supervisory Labour	9,000	9,000	9,000	9,000	9,000	18,000	27,000
Materials	N/A	100	1,722	2,365	N/A	18,000	N/A
Services	N/A	N/A	1,302	240	N/A	2,100	N/A
Building Maintenance	N/A	15,000	354	350[1]	N/A	2,100[1]	N/A
Site Rates	N/A	282,000	N/A	9,470	41,000	89,000	N/A

Insufficient number of cases to carry out analyses on:

Site Vehicle Running Costs

Site Rent

Dept. Admin.

[1] Estimated from transfer and treatment maintenance

N/A Not Available

Wet Pulverisation Capital Costs - First Reduction

	One Pulveriser				Two Pulverisers	
Criteria	t/d 20	58	68	70	184	600
	t/hr 5	10	10	10	20	37.5
Land	← Assumed Leased →					
Site Survey	← No Data Available →					
Pulverisation Equipment (inc. installation)	325,000	525,000	525,000	525,000	625,000	1,250,000
Ancillary Equipment (inc. installation)	2,062	111,879	112,000[1]	112,000[1]	N/A	250,000
Buildings and Civils	N/A	406,422	450,000	500,000	N/A	3,000,000
Other Preparation Costs	N/A	N/A	N/A	8,000	N/A	N/A
Site Vehicle	← No Data Available →					

[1] Based on the costs for similar-sized operations.

N/A Not Available

Wet Pulverisation Operating Costs - First Reduction

Criteria	One Pulveriser					Two Pulverisers		
	t/d 20	40	58	68	70	70	125	184
Transfer and Treatment Equipment Maintenance	2,300	2,500	N/A	5,900	3,450	9,500	30,310[1]	47,112[2]
Electricity	5,862	1,500	N/A	6,500	6,000	12,346	15,000	12,000
Manual Labour	13,800	13,800	13,800	20,700	20,700	20,700	27,500	41,000
Supervisory Labour	9,000	9,000	9,000	9,000	9,000	9,000	9,000	18,000
Materials	364	N/A	1,577	110	6,195	1,748	N/A	9,319
Services	100	N/A	10,450	4,010	850	386	N/A	33,493[3]
Building Maintenance	300	500	2,000	900	750	500	N/A	3,000[3]
Dept. Admin.	833	N/A	N/A	N/A	1,150	9,100	N/A	29,959
Site Rent	0	N/A	N/A	14,000	0	0	24,870	N/A
Site Rates	6,623	1,584	N/A	7,000	9,860	9,727	N/A	N/A

Insufficient number of cases to analyse on-site vehicle running costs.

1 Reduced from aggregated values in raw data.

2 Subsequently found to include landfill costs.

3 Estimated values.

N/A Not Available

APPENDIX 8D

Transfer

Second Reduction Costs and Corresponding R^2 Values

Compaction Transfer without Storage Second Reduction Regressions Capital Costs R^2 Values

Criteria	Daily Tonneage (20-200t/d)		Rated Capacity (5-22t/hr)	
	XY	LogX LogY	XY	LogX LogY
Site Survey and Design	E	E	E	E
Compaction Equip. (Installed cost)	0.85	0.72	0.86*	0.84
Other Ancillar equip. (Installed cost)	E	E	E	E
Building and Civils	0.96*	0.96	0.90	0.63
Other Prep. Costs	E	E	E	E
Total Capital Costs	0.98*	0.94	0.86	0.68

* Largest R^2 value $\geqslant$ 0.70 and relationship used subsequently. XY relationship selected in preference to LogX LogY when both values are identical .

E Empirically derived

Site Acquisition regarded as £0

Compaction Transfer without Storage Second Reduction Regressions Operating Costs R^2 Values

Criteria	Daily Tonneage (20-160t/d)	
	XY	LogX LogY
Compactor Maint.	0.76*	0.56
Electricity	0.59	0.66[1]
Manual Labour	E	E
Supervisory Labour	E	E
Materials	E	E
Services	E	E
Building Maint.	E	E
Dept. Admin	0.89*	0.89
Site Rent	E	E
Site Rates	E	E
Total Capital Costs (excl. capital charges)	0.90*	0.89

* Largest R^2 values ≥ 0.70 and used subsequently

E Empirically derived

1 In the absence of additional information this relationship was used subsequently

Treatment Transfer Second Reduction Regressions, Capital Costs R^2 Values

CRITERIA	BALING				DRY PULVERISATION				WET PULVERISATION			
	Daily Tonneage (t/d)		Rated Capacity (t/hr)		t/d		t/hr		t/d		t/hr	
	XY	LogX LogY	XY	LogX LogY	XY	LogX LogY	XY	LogX LogY	XY	LogX LogY	XY	LogX LogY
Site Survey	E	E	E	E	E	E	E	E	E	E	E	E
Transfer and Treatment Equipment	0.85	0.80	0.99*	0.99	0.73	0.56	0.97*	0.95	0.97*	0.95	0.96	0.94
Ancillary Equipment	0.74*	0.51	0.58	0.46	0.07	0.18	0.75	0.90*	0.78	0.57	0.85*	0.57
Buildings and Civils	0.94*	0.91	0.98	0.90	0.92*	0.56	0.80	0.46	0.99*	0.99	0.95	0.89
Other Prep. Costs	E	E	E	E	E	E	E	E	E	E	E	E
Slave Vehicles	E	E	E	E	E	E	E	E	E	E	E	E
Site Vehicles	E	E	E	E	E	E	E	E	E	E	E	E
Total Capital Costs	0.94*	0.93	0.85	0.76	0.94*	0.67	0.73	0.65	0.99*	0.99	0.98	0.98

* Largest R^2 value $\geqslant$ 0.70 and relationship used in subsequent analyses. XY Plot used where both this and log plot have identical R^2 values

E Empirically derived

Treatment Transfer Second Reduction Regressions, Operating Costs R^2 Values

CRITERIA	BALING		DRY PULVERISATION		WET PULVERISATION	
	XY	LogX LogY	XY	LogX LogY	XY	LogX LogY
Transfer & Treatment Equip. Maintenance	0.99*	0.98	0.63	0.92*	0.91*	0.82
Site Vehicles:						
Fuel	E	E	E	E	E	E
Maint. Labour	E	E	E	E	E	E
Spares	E	E	E	E	E	E
Tyres	E	E	E	E	E	E
Lic. & Ins.	E	E	E	E	E	E
Slave Vehicle Maint.	E	E	E	E	E	E
Electricity	0.97*	0.93	0.98*	0.97	E	E
Manual Labour	E	E	E	E	E	E
Supervisory Labour	E	E	0.97*	0.67	E	E
Materials	0.74*	0.26	E	E	0.79	0.85*
Baling Wire	0.99*	0.99	-	-	-	-
Services	0.88*	0.61	0.68[1]	0.45	E	E
Building Maintenance	E	E	E	E	0.71*	0.65
Dept. Admin	0.97*	0.93	0.96	0.98*	0.98*	0.90
Site Rent	E	E	E	E	E	E
Site Rates	E	E	E	E	E	E
Total Operating Costs (excl. Capital charges)	0.97*	0.93	0.96	0.98*	0.98*	0.90

* Largest R^2 value 0.70 and relationship used in subsequent analyses. XY plot used where both this and log plot have identical R^2 values

E Empirically derived

[1] Function used in absence of additional information

Compaction Transfer without Storage Capital Costs - Second Reduction

	One Compactor			Two Compactors		
Criteria	t/d 20 t/hr 11	49 7	65 11	100 14	160 22	192 22
Site Survey and Design	5408	7219	12058	17039	26488	26024
Compaction Equipment	35000	35000	39992[1]	60000	71859[1]	72000
Other Ancillary Equipment	15000	15000	15000	30000	30000	30000
Buildings and Civils	20000	45000	108840	144478[1]	267008	260000
Other Prep. Costs	7260	8130	8430	8930	9540	9770
Total Capital Costs	82668	110349	184320	260447	404895	397794

[1] Interpolated from 1st reduction cost function

Land acquisition assumed in the base case as £0

Compaction Transfer without Storage Operating Costs - Second Reduction

	One Compactor							Two Compactors	
Criteria	t/d 20	28	31	45	49	65	72	100	160
	t/hr 11	5	7	7	7	11	11	14	22
Compaction equip. maint.	2000	1363[1]	835	1815[1]	1125	2347[1]	2250	4500	4500
Electricity	3000	3600	2500	5625	3416	4663[1]	6466	5000	6832
Manual Labour	13800	13800	13800	13800	13800	20700	20700	26500	26500
Supervisory Labour	2683	2683	2683	2683	2683	4025	4025	5366	5366
Materials	100	140	155	225	245	325	360	500	800
Services	170	170	170	170	170	170	170	300	450
Building Maint.	400	400	400	400	400	400	400	700	1000
Dept. Admin	2693	2770	2626	3137	2873	4037	4244	5210	5664
Site Rent	2893	3321	3462	4034	4177	4690	4891	5596	6785
Site Rates	1880	2158	2250	2622	2715	3049	3179	3637	4410
Total Operating Cost (excl. Capital Charges	29619	30465	28881	34511	31604	44406	46685	57309	62307

[1] Interpolated from 2nd Reduction cost function

Baling Capital Costs - Second Reduction

	One Baler			Two Balers
Criteria	t/d 75	160	200	300
	t/hr 23	30	30	70
Site Survey and Design	32,674	57,710	77,202	198,467
Baling Equipment (inc. installation)	131,040	185,000	185,000	400,000
Ancillary Equipment (inc. installation)	118,384	80,000	400,000	500,000
Buildings and Civils	178,800	500,000	1,045,056 [1]	1,845,000
Other Preparation Costs	8,549	9,434	9,712	10,237
Slave Vehicle	-	-	-	20,000
Site Vehicles	30,000	50,000	50,000	60,000
TOTAL CAPITAL COSTS	499,447	882,144	1,766,970	3,033,704

Land assumed as £0 in the base case.

[1] Interpolated from second reduction cost function.

Baling Operating Costs - Second Reduction

Criteria	One Baler			
	t/d 75	76	160	320
Transfer and Treatment Equipment Maintenance	12,460	12,456[1]	15,000	20,000
Site Vehicles -				
Fuel	1,585	1,596	2,387	3,896
Maint. Lab.	2,505	2,519	3,695	5,935
Spares	878	886	1,551	2,818
Tyres	1,607	1,615	2,266	3,506
Lic. & Ins.	150	150	150	150
Slave Vehicle Maintenance	-	-	-	3,000
Electricity	7,120	5,655	13,760	87,641
Manual Labour	27,500	27,500	34,500	68,640
Supervisory Labour	9,000	9,000	9,000	18,000
Materials	7,550	237	400	27,478
Baling Wire	9,750	9,750	19,500	[2]
Services	100	875	750	3,086
Building Maintenance	400	400	700	1,300
Dept. Admin.	8,881	8,089	11,485	25,732
Site Rent	4,973	5,001	6,785	9,016
Site Rates	3,230	3,247	4,406	5,854
TOTAL OPERATING COST (exc. capital charges)	97,689	88,975	126,335	286,052

[1] Interpolated from second reduction cost function.

[2] Not a wire-tied baler, they are not common at this t/d.

Dry Pulverisation Capital Costs - Second Reduction

Criteria	One Pulveriser			Two Pulverisers	
	t/d 16 t/hr 15	58 9	92 15	180 30	340 30
Site Survey and Design	26,873	31,918	24,723	59,403	94,222
Pulverisation Equipment (inc. installation)	90,000	71,000	90,000	160,000	160,000
Ancillary Equipment (inc. installation)	56,911	46,157	56,911	75,617	75,617
Buildings and Civils	200,000	300,550	157,500	553,423 [1]	1,000,000
Other Preparation Costs	6,993	8,268	8,780	9,579	10,405
Slave Vehicles	-	-	-	-	20,000
Site Vehicles	30,000	30,000	40,000	50,000	80,000
TOTAL CAPITAL COSTS	410,777	487,893	377,914	908,022	1,440,244

[1] Interpolated from second reduction cost function.

Land acquisition assumed in the base case as £0.

Dry Pulverisation Operating Costs - Second Reduction

Criteria	One Pulveriser				Two Pulverisers		
	t/d 16	58	92	92	130	340	600
Transfer and Treatment Equipment Maintenance	3,771	16,800	21,660	16,575	24,000	82,000	56,250
Site Vehicle							
- Fuel	1,029	1,425	1,756	1,756	2,104	4,962	8,292
Maint.Lab.	1,679	2,267	2,743	2,743	3,275	7,670	12,765
Spares	411	743	1,013	1,013	1,314	3,261	5,604
Tyres	1,150	1,476	1,739	1,739	2,034	4,687	7,728
Licences and Insurances	150	150	150	150	150	300	450
Slave Vehicles	-	-	-	-	-	3,000	6,000
Electricity	4,000	14,000	20,068	12,200	20,000	46,000	67,500
Manual Labour	13,800	27,500	41,000	41,000	48,000	89,000	130,500
Supervisory Labour	9,000	9,000	9,000	9,000	9,000	18,000	27,000
Materials	80	290	460	460	650	1,700	3,000
Services	364[1]	589[1]	1,302	240	975[1]	2,100	3,494[1]
Building Maintenance	400	400	400	400	700	1,300	1,800
Dept. Admin.	4,019	8,202	11,021	9,620	12,248	27,623	34,362
Site Rent	2,640	4,476	5,408	5,408	6,232	9,243	11,666
Site Rates	1,714	2,906	3,512	3,512	4,046	6,002	7,575
TOTAL OPERATING COST (exc. capital charges)	44,207	90,224	121,232	105,816	134,728	306,848	383,986

[1] Interpolated from first reduction cost function.

Wet Pulverisation Capital Costs - Second Reduction

Criteria	One Pulveriser				Two Pulverisers	
	t/hr 5	10	10	10	20	37.5
	t/d 20	58	68	70	184	600
Site Survey	41,308	75,710	78,781	82,250	129,697	323,484
Pulverisation Equipment (inc. installation)	325,000	525,000	525,000	525,000	625,000	1,250,000
Ancillary Equipment (inc. installation)	2,062	111,879	112,000	112,000	151,705[1]	250,000
Buildings and Civils	235,859[1]	406,422	450,000	500,000	1,016,500[1]	3,000,000
Other Preparation Costs	7,199	8,268	8,441	8,000	9,607	11,200
Slave Vehicles	-	-	-	-	-	40,000
Site Vehicles	20,000	30,000	30,000	30,000	50,000	150,000
TOTAL CAPITAL COST	631,428	1,157,279	1,204,222	1,257,250	1,982,509	4,944,684

[1] Interpolated from first reduction cost function.

Wet Pulverisation Operating Costs - Second Reduction

Criteria	One Pulveriser					Two Pulverisers		
	t/d 20	40	58	68	70	70	125	184
Transfer and Treatment Equipment Maintenance	2,300	2,500	5,510[1]	5,900	3,450	9,500	15,000[2]	20,000[2]
Site Vehicle								
- Fuel	1,067	1,255	1,425	1,519	1,538	1,538	2,057	2,613
Maint. Lab.	1,735	2,015	2,267	2,407	2,435	2,435	3,205	4,031
Spares	442	601	743	823	838	838	1,274	1,741
Tyres	1,181	1,336	1,476	1,553	1,569	1,569	1,995	2,452
Lic. & Ins.	150	150	150	150	150	150	150	150
Slave Vehicle Maintenance	-	-	-	-	-	-	-	-
Electricity	5,862	6,000[1]	6,000[1]	6,500	6,000	12,346	13,000[1]	12,000
Manual Labour	13,800	13,800	13,800	20,700	20,700	20,700	27,500	41,000
Supervisory Labour	9,000	9,000	9,000	9,000	9,000	9,000	9,000	18,000
Materials	364	1,114[1]	1,577	2,457[1]	6,195	1,748	6,086[1]	9,319
Services	385	492	589	642	653	653	948	1,264
Building Maintenance	300	500	2,000	900	750	500	1,971[1]	3,000
Dept. Admin.	4,136	4,510	5,192	6,043	6,125	6,895	9,230	12,742
Site Rent	2,893	3,844	4,476	4,778	4,835	4,835	6,132	7,186
Site Rates	1,878	2,496	2,906	3,102	3,139	3,139	3,982	4,666
TOTAL OPERATING COSTS (exc. cap. charges)	45,493	49,613	57,111	66,474	67,377	75,846	101,530	140,164

[1] Interpolated from second reduction cost function.

[2] Values reduced from first reduction figures.

APPENDIX 8E

Transfer

Base Case Capital and Operating Component Cost Functions

Component Capital Cost Function for Compaction without Storage over the Range 20-200t/d

Component Cost	One Compactor	Two Compactors	Three Compactors
	Daily Tonneage 0 10 20 30 40 50 60 70	80 90 100 110 120 130 140 150	160 170 180 190 200
Site Survey and Design	$y = 157x_D + 1307$		
Compaction Equipment (Incl. Installation)	$y = 2897x_r + 8125$		
Other Ancillary Equip. (Inc. Installation)	$y = 15000$	$y = 30000$	
Buildings and Civils	$y = 1537x_D - 9222$		
Other Prep. Costs	$y = 4877x_D^{0.13}$		
Total Capital Cost	$y = 2393x_D + 19981$		

Component Operating Cost Functions for Compaction without Storage over the Range 20-200t/d

<table>
<tr><th rowspan="3">Component Cost</th><th colspan="2">One Compactor</th><th colspan="2">Two Compactors</th><th>Three Compactors</th></tr>
<tr><th colspan="5">Daily Tonneage</th></tr>
<tr><th>0 10 20 30 40</th><th>50 60 70</th><th>80 90</th><th>100 110 120 130 140</th><th>150 160 170 180 190 200</th></tr>
<tr><td>Compactor Maintenance</td><td colspan="5">$y = 26.6x_D + 618$</td></tr>
<tr><td>Electricity</td><td colspan="5">$y = 743 x_D^{0.44}$</td></tr>
<tr><td>Manual Labour</td><td>y = 13808</td><td colspan="2">y = 20700</td><td>y = 26500</td><td>y = 34500</td></tr>
<tr><td>Supervisory Labour</td><td>y = 2683</td><td colspan="2">y = 4025</td><td>y = 5366</td><td>y = 6708</td></tr>
<tr><td>Materials</td><td colspan="5">$y = 5x_D$</td></tr>
<tr><td>Services</td><td colspan="2">y = 170</td><td colspan="2">y = 300</td><td>y = 450</td></tr>
<tr><td>Building Maintenance</td><td colspan="2">y = 400</td><td colspan="2">y = 700</td><td>y = 1000</td></tr>
<tr><td>Dept. Admin</td><td colspan="5">$y = 24.8x_D + 2124$</td></tr>
<tr><td>Site Rent</td><td colspan="5">$y = 847 x_D^{0.41}$</td></tr>
<tr><td>Site Rates</td><td colspan="5">$y = 550 x_D^{0.41}$</td></tr>
<tr><td>Total Operating Costs
(incl. Capital Charges)</td><td colspan="5">$y = 272 x_D + 23363$</td></tr>
</table>

Component Capital Cost Function for Compaction with Apron Storage over the Range 20-200t/d

<table>
<tr><th rowspan="3">Component Cost</th><th colspan="3">One Compactor</th><th colspan="2">Two Compactors</th></tr>
<tr><th colspan="5">Daily Tonneage</th></tr>
<tr><th>0 10 20 30 40 50 60 70</th><th>80 90</th><th>100 110 120 130</th><th>140 150</th><th>160 170 180 190 200</th></tr>
<tr><td>Site Survey and Design</td><td colspan="5">$y = 162x_D + 3233$</td></tr>
<tr><td>Compaction Equipment (Incl. Installation)</td><td colspan="5">$y = 2897x_r + 8125$</td></tr>
<tr><td>Other Ancillary Equip. (Inc. Installation)</td><td colspan="2">$y = 15000$</td><td colspan="3">$y = 30000$</td></tr>
<tr><td>Buildings and Civils</td><td colspan="5">$y = 1691x_D - 10144$</td></tr>
<tr><td>Other Prep. Costs</td><td colspan="5">$y = 4877x_D^{0.13}$</td></tr>
<tr><td>Mobile Plant</td><td>$y = 30000$</td><td colspan="3">$y = 40000$</td><td>$y = 50000$</td></tr>
<tr><td>Total Capital Cost</td><td colspan="5">$y = 2406x_D + 53651$</td></tr>
</table>

Component Operating Cost Functions for Compaction with Apron Storage over the Range 20-200t/d

Component Cost	One Compactor	Two Compactors
	Daily Tonneage 0 20 30 40 50 60 70 80 90	100 110 120 130 140 150 160 170 180 190 200
Compactor maintenance, Electricity, Manual Labour, Supervisory Labour, Materials, Site Rents, Site Rates These cost functions are identical to Transfer without Storage		
Services	$y = 170$	$y = 300$
Building Maintenance	$y = 400$	$y = 700$
Mobile Plant:		
Driver	$y = 7500$	
Fuel	$y = 9.43x_D + 878$	
Maintenance Labour	$y = 14.0x_D + 1455$	
Spares	$y = 7.92x_D + 284$	
Tyres	$y = 7.75x_D + 1026$	
Insurance & Lic.	$y = 150$	
Dept. Admin	$y = 26.8x_D + 3303$	
Total Operating Cost (excl. Capital Charges)	$y = 295x_D + 36329$	

Component Capital Cost Functions for Compaction with Bunker Storage over the Range 20-200t/d

Component Cost	One Compactor	Two Compactors
	Daily Tonneage 0 10 20 30 40 50 60 70 80 90 100	110 120 130 140 150 160 170 180 190 200
Site Survey and Design	$y = 273x_D + 11703$	
Compaction Equipment (Incl. Installation)	$y = 2897x_r + 8125$	
Other Ancillary Equip. (Incl. Installation)	$y = 15000$	$y = 30000$
Buildings and Civils	$y = 1691x_D - 10144$	
Other Prep. Costs	$y = 4877x_D^{0.13}$	
Grab Crane/Conveyor System	$y = 26000$	$y = 52000$
Storage Bunker Construction	$y = 200000$	$y = 400000$
Total Capital Cost	$y = 4177x_D + 178887$	

Component Operating Cost Functions for Compaction with Bunker Storage over the Range 20-200t/d

<table>
<tr><th rowspan="3">Component Cost</th><th colspan="2">One Compactor</th><th colspan="2">Two Compactors</th></tr>
<tr><th colspan="4">Daily Tonneage</th></tr>
<tr><th>0 10 20 30 40 50</th><th>60 70 80 90 100</th><th>110 120 130 140 150</th><th>160 170 180 190 200</th></tr>
<tr><td colspan="5">Compactor maintenance, Electricity, Manual Labour, Supervisory Labour, Materials, Site Rents, Site Rates.
These cost functions are identical to Transfer without Storage</td></tr>
<tr><td>Services</td><td colspan="2">$y = 170$</td><td colspan="2">$y = 300$</td></tr>
<tr><td>Building Maintenance</td><td colspan="2">$y = 400$</td><td colspan="2">$y = 700$</td></tr>
<tr><td>Crane Electricity</td><td colspan="2">$y = 13.3x_D + 2149$</td><td colspan="2">$y = 12.2x_D + 4498$</td></tr>
<tr><td>Crane Maintenance</td><td>$y = 520$</td><td>$y = 1040$</td><td>$y = 2080$</td><td>$y = 3120$</td></tr>
<tr><td>Crane Operator(s)</td><td colspan="2">$y = 7500$</td><td colspan="2">$y = 15000$</td></tr>
<tr><td>Dept. Admin</td><td colspan="4">$y = 35.4x_D + 3116$</td></tr>
<tr><td>Total Operating Cost
(excl. Capital Charges)</td><td colspan="4">$y = 361x_D + 31301$</td></tr>
</table>

Component Capital Cost Functions for Wire-tied Baling over the Range 75-300t/d

<table>
<tr><th rowspan="3">Component Cost</th><th colspan="14">One Baler</th><th colspan="10">Two Balers</th></tr>
<tr><th colspan="24">Daily Tonneage</th></tr>
<tr><th>70</th><th>80</th><th>90</th><th>100</th><th>110</th><th>120</th><th>130</th><th>140</th><th>150</th><th>160</th><th>170</th><th>180</th><th>190</th><th>200</th><th>210</th><th>220</th><th>230</th><th>240</th><th>250</th><th>260</th><th>270</th><th>280</th><th>290</th><th>300</th></tr>
<tr><td>Site Survey and Design</td><td colspan="24">$y = 3407x_r - 38789$</td></tr>
<tr><td>Baling Equipment (Incl. Installation)</td><td colspan="24">$y = 5556x_r + 12745$</td></tr>
<tr><td>Ancillary Equipment (Incl. Installation)</td><td colspan="24">$y = 1905x_D - 75443$</td></tr>
<tr><td>Buildings and Civils</td><td colspan="24">$y = 6774x_D - 309744$</td></tr>
<tr><td>Other Prep. Costs</td><td colspan="24">$y = 4877x_D^{0.13}$</td></tr>
<tr><td>Slave Vehicles</td><td colspan="12">< 300t/d $y = 0$</td><td colspan="12">$\geqslant 300$t/d $y = 20000$</td></tr>
<tr><td>Site Vehicles</td><td colspan="9">$y = 40000$</td><td colspan="8">$y = 50000$</td><td colspan="7">$y = 60000$</td></tr>
<tr><td>Total Capital Costs</td><td colspan="24">$y = 11698x_D - 603896$</td></tr>
</table>

Component Operating Cost Functions for Baling over the range 75-320t/d

Component Cost	One Baler	Two Balers
	Daily Tonneage 70 80 90 100 110 120 130 140 150 160 170 180 190 200	210 220 230 240 250 260 270 280 290 300 310 320
Transfer & Treatment Maintenance	$y = 30.8_{D} + 10115$	
Site Vehicles: Fuel	$y = 9.43x_D + 878$	$y = 9.43x_D + 1756$
Maintenance Lab.	$y = 14.0x_D + 1455$	$y = 14.0x_D + 2910$
Spares	$y = 7.92x_D + 284$	$y = 7.92x_D + 568$
Tyres	$y = 7.75x_D + 1026$	$y = 7.75x_D + 2052$
Lic. & Ins.	$y = 150$	$y = 300$
Slave Vehicle		$y = 3000$
Electricity	$y = 87.1x_D - 183$	$y = 87.1x_D + 183$
Manual Labour	$y = 27500$ $y = 34500$	$y = 41000$ $y = 55000$ $y = 68600$
Supervisory Labour	$y = 9000$	$y = 18000$
Materials	$y = 95.7x_D - 6182$	
Baling Wire	$y = 115x_D + 1040$	
Services	$y = 10.6x_D - 470$	
Building Maint.	$y = 400$ $y = 700$	$y = 1000$ $y = 1300$
Dept. Admin	$y = 70.4x_D + 2447$	
Site Rent	$y = 847x_D^{0.41}$	
Site Rates	$y = 550x_D^{0.41}$	
Total Operating Costs (excl. Capital Charges)	$y = 786x_D + 25739$	

Component Capital Cost Functions for Dry Pulverisation over the range 20-340t/d

Component Cost	One Pulveriser							Two Pulverisers									
	Daily Tonneage																
	20	40	60	80	100	120	140	160	180	200	220	240	260	280	300	320	340
Site Survey and Design	$y = 224x_D + 16753$																
Pulverisation Equip. (Incl. Installation)	$y = 4391x_r + 35427$																
Ancillary Equipment (Incl. Installation)	$y = 18750x_r^{0.41}$																
Buildings and Civils	$y = 2597x_D + 85963$																
Other Prep. Costs	$y = 4877x_D^{0.13}$																
Slave Vehicle	–														y=20000		
Site Vehicles	y = 30000			y = 40000				y = 50000				y = 60000			y=80000		
Total Capital Costs	$y = 3418x_D + 256087$																

Component Operating Cost Functions for Dry Pulverisation over the Range 20-600t/d

Component Cost	One Pulveriser							Two Pulverisers																						
	Daily Tonneage																													
	20	40	60	80	100	120	140	160	180	200	220	240	260	280	300	320	340	360	380	400	420	440	460	480	500	520	540	560	580	600
Transfer & Treatment Maintenance	$y = 502x_D^{0.80}$																													
Site Vehicle:																														
Fuel	$y = 9.43x_D + 878$												$y = 9.43x_D + 1756$												$y = 9.43x_D + 2634$					
Maintenance Labour	$y = 14.0x_D + 1455$												$y = 14.0x_D + 2910$												$y = 14.0x_D + 4365$					
Spares	$y = 7.92x_D + 284$												$y = 7.92x_D + 568$												$y = 7.92x_D + 852$					
Tyres	$y = 7.75x_D + 1026$												$y = 7.75x_D + 2052$												$y = 7.75x_D + 3078$					
Licence & Insurance	$y = 150$												$y = 300$												$y = 450$					
Slave Vehicle Maint.	–														$y = 3000$								$y = 6000$							
Electricity	$y = 106x_D + 6111$																													
Manual Labour	$y=13800$	$y=27500$		$y = 41000$				$y = 61800$		$y = 82400$					$y = 96100$					$y = 109800$					$y = 123600$					
Supervisory Labour	$y = 9000$												$y = 18000$												$y = 27000$					
Materials	$y = 5x_D$																													
Services	$y = 5.36x_D + 278$																													
Building Maintenance	$y=400$				$y = 700$					$y = 1000$					$y = 1300$					$y = 1600$					$y = 1800$					
Dept. Admin	$y = 679x_D^{0.61}$																													
Site Rent	$y = 847x_D^{0.41}$																													
Site Rates	$y = 550x_D^{0.41}$																													
Total Operating Costs (excl. Capital Charges)	$y = 7340x_D^{0.62}$																													

Component Capital Cost Functions for Wet Pulverisation over the Range 20-600t/d

<table>
<tr><th rowspan="3">Component Cost</th><th colspan="8">One Pulveriser</th><th colspan="23">Two Pulverisers</th></tr>
<tr><th colspan="31">Daily Tonneage</th></tr>
<tr><th>0</th><th>20</th><th>40</th><th>60</th><th>80</th><th>100</th><th>120</th><th>140</th><th>160</th><th>180</th><th>200</th><th>220</th><th>240</th><th>260</th><th>280</th><th>300</th><th>320</th><th>340</th><th>360</th><th>380</th><th>400</th><th>420</th><th>440</th><th>460</th><th>480</th><th>500</th><th>520</th><th>540</th><th>560</th><th>580</th><th>600</th></tr>
<tr><td>Site Survey & Design</td><td colspan="31">$y = 467x_D + 43961$</td></tr>
<tr><td>Pulverisation Equip. (Incl Installation)</td><td colspan="31">$y = 1436x_D + 389897$</td></tr>
<tr><td>Ancillary Equipment (Inc. Installation)</td><td colspan="31">$y = 6204x_r + 27625$</td></tr>
<tr><td>Buildings and Civils</td><td colspan="31">$y = 4760x_D + 140659$</td></tr>
<tr><td>Other Prep. Costs</td><td colspan="31">$y = 4877x_D^{0.13}$</td></tr>
<tr><td>Slave Vehicle</td><td colspan="15"></td><td colspan="8">$y = 20000$</td><td colspan="8">$y = 40000$</td></tr>
<tr><td>Site Vehicle</td><td colspan="4">$y = 30000$</td><td colspan="4">$y = 40000$</td><td colspan="4">$y = 50000$</td><td colspan="3">$y = 60000$</td><td colspan="5">$y = 80000$</td><td colspan="5">$y = 100000$</td><td colspan="6">$y = 120000$</td></tr>
<tr><td>Total Capital Costs</td><td colspan="31">$y = 7146x_D + 671971$</td></tr>
</table>

Component Operating Cost Functions for Wet Pulverisation over the Range 20-250t/d

Component Cost	One Pulveriser													Two Pulverisers										
	Daily Tonneage																							
	20	30	40	50	60	70	80	90	100	110	120	130	140	150	160	170	180	190	200	210	220	230	240	250
Transfer & Treatment Equip. Maintenance	$y = 119x_D - 1392$																							
Site Vehicle:																								
Fuel	$y = 9.43x_D + 878$																							
Maintenance Labour	$y = 14.0x_D + 1455$																							
Spares	$y = 7.92x_D + 284$																							
Tyres	$y = 7.75x_D + 1026$																							
Licence & Insurance	$y = 150$																							
Electricity	$y = 6000$														$y = 13000$									
Manual Labour	$y = 13800$					$y = 20600$				$y = 27500$				$y = 34500$			$y = 41000$				$y = 48000$			
Supervisory Labour	$y = 9000$													$y = 18000$										
Materials	$y = 4.57x_D^{1.49}$																							
Services	$y = 5.36x_D + 278$																							
Building Maintenance	$y = 16.0x_D - 29$																							
Dept. Admin	$y = 54.6x_D + 2528$																							
Site Rent	$y = 847x_D^{0.41}$																							
Site Rates	$y = 550x_D^{0.41}$																							
Total Operating Cost (excl. Capital Charges)	$y = 600x_D + 27813$																							

APPENDIX 8F

Transfer:

Base Case Capital and Operating Costs

```
*****************************************************************************************
BASE CASE COSTS AT SELECTED DAILY TONNEAGES FOR LANDFILL-RELATED DISPOSAL METHODS
*****************************************************************************************


                    COMPACTION TRANSFER WITHOUT STORAGE
                    ***********************************

CAPITAL COSTS   (RANGE 25 TO 200 TONNES PER DAY)

T/D             25.       30.       40.       50.       60.       75.       80.       90.      100.      125.      150.      175.      200.
RATED CAP        5.        5.       11.       11.       11.       15.       15.       15.       16.       22.       22.       27.       33.
***************************************************************************************************************************************

SURVEY        5232.0    6017.0    7587.0    9157.0   10727.0   13082.0   13867.0   15437.0   17007.0   20932.0   24857.0   28782.0   32707.0

BUILDINGS    29203.0   36888.0   52258.0   67628.0   82998.0  106053.0  113738.0  129108.0  144478.0  182903.0  221328.0  259753.0  298178.0

COMPACTOR    22610.0   22610.0   39992.0   39992.0   39992.0   51580.0   51580.0   51580.0   54477.0   71859.0   71859.0   86344.0  103726.0

PREPARE       7411.1    7588.9    7878.1    8110.0    8304.5    8548.9    8620.9    8754.0    8874.7    9135.9    9355.0    9544.4    9711.5

ANCILLARY    15000.0   15000.0   15000.0   15000.0   15000.0   15000.0   30000.0   30000.0   30000.0   30000.0   30000.0   30000.0   30000.0
***************************************************************************************************************************************

SUM.TOTAL    79456.1   88103.9  122715.1  139887.0  157021.5  194263.9  217805.9  234879.0  254836.7  314829.9  357399.0  414423.4  474322.5

CAPITAL COSTS AMORTISED OVER 10Y AT 14%PA -  COMPACTION AND ANCILLARY EQUIPMENT
   "     "     "       " 20Y AT 14%PA - BUILDINGS AND SITE PREPARATIONS
```

<u>Compaction without Storage</u>

```
OPERATING COSTS    (RANGE 25 TO 200 TONNES PER DAY)

T/D             25.      30.      40.      50.      60.      75.      80.      90.     100.     125.     150.     175.     200.
**************************************************************************************************************************

COMPCT MT     1283.0   1416.0   1682.0   1948.0   2214.0   2613.0   2746.0   3012.0   3278.0   3943.0   4608.0   5273.0   5938.0

ELECTRIC      3062.5   3318.3   3766.1   4154.7   4501.7   4966.1   5109.1   5380.9   5636.2   6217.7   6737.0   7209.8   7646.1

LABOUR       13800.0  13800.0  13800.0  13800.0  20700.0  20700.0  20700.0  20700.0  20700.0  26500.0  26500.0  34500.0  34500.0

SUPER.LAB     2683.0   2683.0   2683.0   2683.0   4025.0   4025.0   4025.0   4025.0   4025.0   5366.0   5366.0   6708.0   6708.0

MATERIALS      125.0    150.0    200.0    250.0    300.0    375.0    400.0    450.0    500.0    625.0    750.0    875.0   1000.0

SERVICES       170.0    170.0    170.0    170.0    170.0    170.0    300.0    300.0    300.0    300.0    300.0    450.0    450.0

BUILD.MT       400.0    400.0    400.0    400.0    400.0    400.0    700.0    700.0    700.0    700.0    700.0   1000.0   1000.0

ADMIN         2744.0   2868.0   3116.0   3364.0   3612.0   3984.0   4108.0   4356.0   4604.0   5224.0   5844.0   6464.0   7084.0

RENT          3169.9   3415.9   3843.5   4211.7   4538.6   4973.5   5106.8   5359.5   5596.1   6132.2   6608.2   7039.3   7435.4

RATES         2058.3   2218.1   2495.8   2734.9   2947.2   3229.5   3316.1   3480.2   3633.8   3981.9   4291.0   4571.0   4828.2

**************************************************************************************************************************

SUM.TOTAL    29495.7  30439.3  32156.4  33716.3  43408.5  45436.1  46511.1  47763.6  48973.1  58989.8  61704.2  74090.1  76589.8
(EXCLUDING CAPTIAL CHARGES)


CP.CHARGE    12738.6  13925.7  19622.4  21978.1  24328.1  30067.6  34114.5  36455.2  39349.5  48522.9  54357.7  62964.9  72124.1
**************************************************************************************************************************

SUM.TOTAL    42234.3  44365.1  51778.8  55694.4  67736.6  75503.7  80625.6  84218.8  88322.6 107512.8 116061.9 137055.0 148713.9
(INCLUDING CAPTIAL CHARGES)
```

```
*********************************************************************************
BASE CASE COSTS AT SELECTED DAILY TONNEAGES FOR LANDFILL-RELATED DISPOSAL METHODS
*********************************************************************************


                      COMPACTION TRANSFER WITH APRON STORAGE
                      **************************************

CAPITAL COSTS   (RANGE 25 TO 200 TONNES PER DAY)

T/O            25.      30.      40.      50.      60.      70.      80.      90.     100.     125.     150.     175.     200.
RATED CAP       5.       5.      11.      11.      11.      11.      11.      15.      15.      16.      22.      22.      30.
*****************************************************************************************************************************

SURVEY       7283.0   8093.0   9713.0  11333.0  12953.0  14573.0  16193.0  17813.0  19433.0  23483.0  27533.0  31583.0  35633.0

BUILDINGS   32131.0  40586.0  57496.0  74406.0  91316.0 108226.0 125136.0 142046.0 158956.0 201231.0 243506.0 285781.0 328056.0

PREPARE      7411.1   7588.9   7678.1   8110.0   8304.5   8472.6   8620.9   8754.0   8874.7   9135.9   9355.0   9544.4   9711.5

COMPACTOR   22610.0  22610.0  39992.0  39992.0  39992.0  39992.0  39992.0  51580.0  51580.0  54477.0  71859.0  71859.0  95035.0

ANCILLARY   15000.0  15000.0  15000.0  15000.0  15000.0  15000.0  15000.0  15000.0  15000.0  30000.0  30000.0  30000.0  30000.0

MOBILE PT   30000.0  30000.0  30000.0  30000.0  30000.0  30000.0  40000.0  40000.0  40000.0  40000.0  40000.0  50000.0  50000.0

*****************************************************************************************************************************

SUM.TOTAL 114435.1 123877.9 160079.1 176841.0 197565.5 216263.6 244941.9 275193.0 293843.7 358326.9 422253.0 478767.4 548435.5

CAPITAL COSTS AMORTISED OVER 10Y AT 14%PA -  COMPACTION AND ANCILLARY EQUIPMENT
   "      "      "       " 20Y AT 14%PA - BUILDINGS AND SITE PREPARATIONS
   "      "      "       "  5Y AT 14%PA - MOBILE PLANT
```

Compaction with Apron Storage

```
OPERATING COSTS    (RANGE 25 TO 200 TONNES PER DAY)

T/D             25.       30.       40.       50.       60.       70.       80.       90.      100.      125.      150.      175.      200.
************************************************************************************************************************************

COMPCT MT     1283.0    1416.0    1682.0    1948.0    2214.0    2480.0    2746.0    3012.0    3278.0    3943.0    4608.0    5273.0    5938.0

ELECTRIC      3062.5    3318.3    3766.1    4154.7    4501.7    4817.6    5109.1    5380.9    5636.2    6217.7    6737.0    7209.8    7646.1

DRIVER        7500.0    7500.0    7500.0    7500.0    7500.0    7500.0    7500.0    7500.0    7500.0    7500.0    7500.0    7500.0    7500.0

VEH.FUEL      1113.8    1160.9    1255.2    1349.5    1443.8    1538.1    1632.4    1726.7    1821.0    2056.8    2292.5    2528.3    2764.0

V.MT.LAB      1805.0    1875.0    2015.0    2155.0    2295.0    2435.0    2575.0    2715.0    2855.0    3205.0    3555.0    3905.0    4255.0

V.SPARES       482.0     521.6     600.8     680.0     759.2     838.4     917.6     996.8    1076.0    1274.0    1472.0    1670.0    1868.0

V.TYRES       1219.8    1258.5    1336.0    1413.5    1491.0    1568.5    1646.0    1723.5    1801.0    1994.8    2188.5    2382.3    2576.0

VEH.LIC        150.0     150.0     150.0     150.0     150.0     150.0     150.0     150.0     150.0     150.0     150.0     150.0     150.0

LABOUR       13800.0   13800.0   13800.0   13800.0   20700.0   20700.0   20700.0   20700.0   20700.0   26500.0   26500.0   34500.0   34500.0

SUPER.LAB     2683.0    2683.0    2683.0    2683.0    4025.0    4025.0    4025.0    4025.0    4025.0    5366.0    5366.0    6708.0    6708.0

MATERIALS      125.0     150.0     200.0     250.0     300.0     350.0     400.0     450.0     500.0     625.0     750.0     875.0    1000.0

SERVICES       170.0     170.0     170.0     170.0     170.0     170.0     170.0     170.0     170.0     300.0     300.0     300.0     300.0

BUILD.MT       400.0     400.0     400.0     400.0     400.0     400.0     400.0     400.0     400.0     700.0     700.0     700.0     700.0

ADMIN         3973.0    4107.0    4375.0    4643.0    4911.0    5179.0    5447.0    5715.0    5983.0    6653.0    7323.0    7993.0    8663.0

RENT          3169.9    3415.9    3843.5    4211.7    4538.6    4834.7    5106.8    5359.5    5596.1    6132.2    6608.2    7039.3    7435.4

RATES         2056.3    2218.1    2495.8    2734.9    2947.2    3139.4    3316.1    3480.2    3633.8    3961.9    4291.0    4571.0    4828.2

************************************************************************************************************************************

SUM.TOTAL    42995.2   44144.3   46272.4   48243.3   58346.5   60125.8   61841.1   63504.6   65125.1   76599.4   80341.2   93304.6   96831.8
(EXCLUDING CAPITAL CHARGES)


CP.CHARGE    21919.2   23222.6   29151.8   31740.0   34322.5   36901.1   42389.5   47184.3   49755.7   59609.2   69357.6   78681.9   89533.3

************************************************************************************************************************************

SUM.TOTAL    64914.4   67366.9   75424.2   79983.3   92669.0   97026.9  104230.6  110688.9  114880.8  136208.5  149698.8  171986.5  186365.0
(INCLUDING CAPITAL CHARGES)
```

```
******************************************************************************

BASE CASE COSTS AT SELECTED DAILY TONNAGES FOR LANDFILL-RELATED DISPOSAL METHODS

******************************************************************************


                    COMPACTION TRANSFER WITH BUNKER STORAGE
                    ***************************************

CAPITAL COSTS   (RANGE 25 TO 200 TONNES PER DAY)

T/D            25.      30.      40.      50.      60.      75.      80.      90.     100.     125.     150.     175.     200.
RATED CAP       5.       5.      11.      11.      11.      11.      11.      15.      15.      16.      22.      22.      30.
******************************************************************************************************************************

SURVEY     18528.0  19893.0  22623.0  25353.0  28083.0  32178.0  33543.0  36273.0  39003.0  45828.0  52653.0  59478.0  66303.0

BUILDINGS  32131.0  40586.0  57496.0  74406.0  91316.0 116681.0 125136.0 142046.0 158956.0 201231.0 243506.0 285781.0 328056.0

PREPARE     7411.1   7598.9   7878.1   8110.0   8304.5   8548.9   8620.9   8754.0   8874.7   9135.9   9355.0   9544.4   9711.5

COMPACTOR  22610.0  22610.0  39992.0  39992.0  39992.0  39992.0  39992.0  51580.0  51580.0  54477.0  71859.0  71859.0  95035.0

ANCILLARY  15000.0  15000.0  15000.0  15000.0  15000.0  15000.0  15000.0  15000.0  15000.0  30000.0  30000.0  30000.0  30000.0

O/H CRANE OR CONVEYOR SYSTEM
           26000.0  26000.0  26000.0  26000.0  26000.0  26000.0  26000.0  26000.0  26000.0  52000.0  52000.0  52000.0  52000.0

BUNKER    200000.0 200000.0 200000.0 200000.0 200000.0 200000.0 200000.0 200000.0 200000.0 400000.0 400000.0 400000.0 400000.0

******************************************************************************************************************************

SUM.TOTAL 321680.2 331677.9 368989.1 388861.0 408695.5 438399.9 448291.9 479653.0 499413.7 792671.9 859373.1 908662.4 981105.5

CAPITAL COSTS AMORTISED OVER 10Y AT 14%PA - GRAB CRANE/CONVEYOR SYSTEM, COMPACTION AND ANCILLARYEQUIPMENT
   "      "       "     "  20Y AT 14%PA - BUNKER CONSTRUCTION, BUILDINGS AND SITE PREPARATIONS
```

Compaction with Bunker Storage

```
OPERATING COSTS    (RANGE 25 TO 200 TONNES PER DAY)

T/D              25.       30.       40.       50.       60.       75.       80.       90.      100.      125.      150.      175.      200.
****************************************************************************************************************************************

COMPCT MT    1283.0    1416.0    1682.0    1948.0    2214.0    2613.0    2746.0    3012.0    3278.0    3943.0    4608.0    5273.0    5938.0

ELECTRIC     3062.5    3318.3    3760.1    4154.7    4501.7    4966.1    5109.1    5380.9    5636.2    6217.7    6737.0    7209.8    7646.1

LABOUR      13800.0   13800.0   13800.0   13800.0   20700.0   20700.0   20700.0   20700.0   20700.0   26500.0   26500.0   34500.0   34500.0

SUPER.LAB    2683.0    2683.0    2683.0    2683.0    4025.0    4025.0    4025.0    4025.0    4025.0    5366.0    5366.0    6708.0    6708.0

MATERIALS     125.0     150.0     200.0     250.0     300.0     375.0     400.0     450.0     500.0     625.0     750.0     875.0    1000.0

SERVICES      170.0     170.0     170.0     170.0     170.0     170.0     170.0     170.0     170.0     300.0     300.0     300.0     300.0

BUILD.MT      400.0     400.0     400.0     400.0     400.0     400.0     400.0     400.0     400.0     700.0     700.0     700.0     700.0

GRAB ELEC    2481.5    2548.0    2681.0    2814.0    2947.0    3146.5    3213.0    3346.0    3479.0    6023.0    6326.0    6633.0    6938.0

GRAB MT       520.0     520.0     520.0     520.0    1040.0    1040.0    1040.0    1040.0    1040.0    2080.0    2080.0    3120.0    3120.0

GRAB OP      7500.0    7500.0    7500.0    7500.0    7500.0    7500.0    7500.0    7500.0    7500.0   15000.0   15000.0   15000.0   15000.0

ADMIN        4001.0    4178.0    4532.0    4886.0    5240.0    5771.0    5948.0    6302.0    6656.0    7541.0    8426.0    9311.0   10196.0

RENT         3169.9    3415.9    3803.5    4211.7    4538.6    4973.5    5106.8    5359.5    5596.1    6132.2    6608.2    7039.3    7435.4

RATES        2056.3    2218.1    2495.8    2730.9    2947.2    3229.5    3316.1    3480.2    3633.8    3981.9    4291.0    4571.0    4826.2
****************************************************************************************************************************************

SUM.TOTAL   41254.2   42317.3   44273.4   46072.3   56523.5   58909.6   59674.1   61165.6   62614.1   84409.9   87694.2  101240.1  104309.8
(EXCLUDING CAPITAL CHARGES)


CP.CHARGE   48362.4   49665.8   55595.0   58183.2   60765.8   64632.4   65919.9   70714.7   73286.1  118321.3  128069.7  134481.3  145332.6
****************************************************************************************************************************************

SUM.TOTAL   89616.7   91983.2   99868.5  104255.5  117289.3  123542.0  125594.0  131880.3  135900.3  202731.2  215764.0  235721.3  249642.3
(INCLUDING CAPITAL CHARGES)
```

```
************************************************************************

BASE CASE COSTS AT SELECTED DAILY TONNEAGES FOR LANDFILL-RELATED DISPOSAL METHODS

************************************************************************


                       DRY PULVERIATION AND TRANSFER (APRON STORAGE ASSUMED)
                       ****************************************************

CAPITAL COSTS    (RANGE 25 TO 340 TONNES PER DAY)
                 MODEL EXTRAPOLATED UPTO 600 T/D TO ENABLE COMPARISON WITH THE RANGE OF OPERATING COSTS

T/D             25.       50.       75.      100.      125.      150.      200.      250.      300.      350.      400.      500.      600.
RATED CAP        9.        9.        9.       15.       15.       15.       18.       18.       30.       30.       35.       35.       40.
***************************************************************************************************************************

SURVEY     22353.0   27953.0   33553.0   39153.0   44753.0   50353.0   61553.0   72753.0   83953.0   95153.0  106353.0  128753.0  151153.0

BUILDINGS 150888.0  215813.0  280738.0  345663.0  410588.0  475513.0  605363.0  735213.0  865063.0  994913.01124763.01384463.01644163.0

PREPARE     7411.1    8110.0    8546.9    8874.7    9135.9    9355.0    9711.5    9997.4   10237.1   10444.4   10627.2   10940.0   11202.4

PULVERISER
           74946.0   74946.0   74946.0  101292.0  101292.0  101292.0  114465.0  114465.0  167157.0  167157.0  189112.0  189112.0  211067.0

ANCILLARY  46157.3   46157.3   46157.3   56911.3   56911.3   56911.3   61328.6   61328.6   75617.3   75617.3   80550.7   80550.7   85083.6

MOBILE PLANT - LOADING SHOVEL
           30000.0   30000.0   30000.0   40000.0   40000.0   40000.0   50000.0   60000.0   60000.0   80000.0   80000.0  100000.0  120000.0

MOBILE PLANT - SLAVE VEHICLE
               0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0   20000.0   20000.0   20000.0   40000.0   40000.0

***************************************************************************************************************************

SUM.TOTAL  331756.   402979.   473943.   591894.   662680.   733424.   902421.  1053757.  1282027.  1443285.  1611406.  1933819.  2262669.

CAPITAL COSTS AMORTISED OVER 10Y AT 14%PA - PULVERISER AND ANCILLARY  EQUIPMENT
   "      "       "      "   20Y AT 14%PA - BUILDINGS AND SITE PREPARATIONS
   "      "       "      "    5Y AT 14%PA - LOADING SHOVELS AND SLAVE VEHICLES
```

Dry Pulverisation

```
OPERATING COSTS    (RANGE 25 TO 600 TONNES PER DAY)

T/D             25.       50.       75.      100.      125.      150.      200.      250.      300.      350.      400.      500.      600.
*****************************************************************************************************************************************

PULV.MT     6592.6   11478.4   15876.4   19985.0   23890.9   27642.5   34795.9   41596.4   48128.3   54445.0   60583.1   72423.6   83796.3

ELECTRIC    8761.0   11411.0   14061.0   16711.0   19361.0   22011.0   27311.0   32611.0   37911.0   43211.0   48511.0   59111.0   69711.0

VEH.FUEL    1113.8    1349.5    1585.3    1821.0    2056.8    2292.5    2764.0    3235.5    4585.0    5056.5    5528.0    6471.0    8292.0

V.MT.LAB    1805.0    2155.0    2505.0    2855.0    3205.0    3555.0    4255.0    4955.0    7110.0    7810.0    8510.0    9910.0   12765.0

V.SPARES     482.0     680.0     878.0    1076.0    1274.0    1472.0    1868.0    2264.0    2944.0    3340.0    3736.0    4528.0    5604.0

V.TYRES     1219.8    1413.5    1607.3    1801.0    1994.8    2188.5    2576.0    2963.5    4377.0    4764.5    5152.0    5927.0    7728.0

VEH.LIC      150.0     150.0     150.0     150.0     150.0     150.0     150.0     150.0     300.0     300.0     300.0     300.0     450.0

SLAVE VEHICLE (COMBINED OPERATING COST)
               0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0    3000.0    3000.0    3000.0    6000.0    6000.0

LABOUR     13800.0   27500.0   27500.0   41000.0   41000.0   61800.0   61800.0   82400.0   82400.0   96100.0   96100.0  109800.0  123600.0

SUPER.LAB   9000.0    9000.0    9000.0    9000.0    9000.0    9000.0    9000.0    9000.0   18000.0   18000.0   18000.0   18000.0   27000.0

MATERIALS    125.0     250.0     375.0     500.0     625.0     750.0    1000.0    1250.0    1500.0    1750.0    2000.0    2500.0    3000.0

SERVICES     412.0     546.0     680.0     814.0     948.0    1082.0    1350.0    1618.0    1886.0    2154.0    2422.0    2958.0    3494.0

BUILD.MT     400.0     400.0     400.0     400.0     700.0     700.0     700.0    1000.0    1000.0    1300.0    1300.0    1600.0    1800.0

ADMIN       4837.4    7383.1    9454.9   11268.6   12911.7   14430.6   17198.8   19706.7   22024.9   24196.4   26249.6   30077.5   33615.7

RENT        3169.9    4211.7    4973.5    5596.1    6132.2    6608.2    7435.4    8147.8    8780.2    9353.0    9879.3   10825.8   11666.1

RATES       2058.3    2734.9    3229.5    3633.8    3981.9    4291.0    4828.2    5290.8    5701.4    6073.4    6415.2    7029.8    7575.4
*****************************************************************************************************************************************

SUM.TOTAL  53926.7   80663.1   92275.8  116611.5  127231.3  157973.3  177032.3  216188.6  249647.8  280853.8  297686.5  347461.6  406097.5
(EXCLUDING CAPITAL CHARGES)


CP.CHARGE  55856.6   65764.9   75633.9   95511.3  105353.5  115189.3  141133.8  163695.4  202003.9  227466.4  252254.4  303164.0  353318.4
*****************************************************************************************************************************************

SUM.TOTAL 109783.3  146428.0  167909.8  212122.8  232584.8  273162.6  318166.1  379884.0  451651.7  508320.2  549940.9  650625.6  759415.9
(INCLUDING CAPITAL CHARGES)
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*****************************************************************************
BASE CASE COSTS AT SELECTED DAILY TONNEAGES FOR LANDFILL-RELATED DISPOSAL METHODS
*****************************************************************************


                        WET PULVERIATION AND TRANSFER (APRON STORAGE ASSUMED)
                        ****************************************************

CAPITAL COSTS    (RANGE 25 TO 600 TONNES PER DAY)

T/D             25.      50.      75.     100.     125.     150.     200.     250.     300.     350.     400.     500.     600.
RATED CAP        5.      10.      10.      15.      15.      20.      20.      30.      30.      35.      35.      35.      40.
******************************************************************************************************************************

SURVEY     55636.0  67311.0  78986.0  90661.0 102336.0 114011.0 137361.0 160711.0 184061.0 207411.0 230761.0 277461.0 324161.0

BUILDINGS 259659.0 378659.0 497659.0 616659.0 735659.0 854659.01092659.01330659.01568659.01806659.02044659.02520659.02996659.0

PREPARE     7411.1   8110.0   8548.9   8874.7   9135.9   9355.0   9711.5   9997.4  10237.1  10444.4  10627.2  10940.0  11202.4

PULVERISER
          425797.0 461697.0 497597.0 533497.0 569397.0 605297.0 677097.0 748897.0 820697.0 892497.0 964297.01107897.01251497.0

ANCILLARY  58645.0  89665.0  89665.0 120685.0 120685.0 151705.0 151705.0 213745.0 213745.0 244765.0 244765.0 244765.0 275785.0

MOBILE PLANT - LOADING SHOVEL
           30000.0  30000.0  30000.0  40000.0  40000.0  40000.0  50000.0  60000.0  60000.0  80000.0  80000.0 100000.0 120000.0

MOBILE PLANT - SLAVE VEHICLE
               0.0      0.0      0.0      0.0      0.0      0.0      0.0      0.0  20000.0  20000.0  20000.0  40000.0  40000.0

******************************************************************************************************************************

SUM.TOTAL  837148. 1035442. 1202456. 1410377. 1577213. 1775027. 2118534. 2524010. 2877399. 3261777. 3595109. 4301722. 5019305.

CAPITAL COSTS AMORTISED OVER 10Y AT 14%PA - PULVERISER AND ANCILLARY  EQUIPMENT
  "      "        "      "   20Y AT 14%PA - BUILDINGS AND SITE PREPARATIONS
  "      "        "      "    5Y AT 14%PA - LOADING SHOVELS AND SLAVE VEHICLES
```

Wet Pulverisation

```
OPERATING COSTS    (RANGE 25 TO 250 TONNES PER DAY)
                  MODEL EXTRAPOLATED UPTO 600 T/D TO ENABLE COMPARISON WITH THE RANGE OF CAPITAL COSTS
T/O              25.      50.      75.     100.     125.     150.     200.     250.     300.     350.     400.     500.     600.
*********************************************************************************************************************************

PULV.MT        1583.0   4558.0   7533.0  10508.0  13483.0  16458.0  22408.0  28358.0  34308.0  40258.0  46208.0  58108.0  70008.0

ELECTRIC       6000.0   6000.0   6000.0   6000.0   6000.0   6000.0  13000.0  13000.0  13000.0  19000.0  19000.0  25000.0  25000.0

VEH.FUEL       1113.8   1349.5   1585.3   1821.0   2056.8   2292.5   2764.0   3235.5   4585.0   5056.5   5528.0   6471.0   8292.0

V.MT.LAB       1805.0   2155.0   2505.0   2855.0   3205.0   3555.0   4255.0   4955.0   7110.0   7810.0   8510.0   9910.0  12765.0

V.SPARES        482.0    680.0    878.0   1076.0   1274.0   1472.0   1868.0   2264.0   2944.0   3340.0   3736.0   4528.0   5604.0

V.TYRES        1219.8   1413.5   1607.3   1801.0   1994.8   2188.5   2576.0   2963.5   4377.0   4764.5   5152.0   5927.0   7728.0

VEH.LIC         150.0    150.0    150.0    150.0    150.0    150.0    150.0    150.0    300.0    300.0    300.0    300.0    450.0

SLAVE VEHICLE (COMBINED OPERATING COST)
                  0.0      0.0      0.0      0.0      0.0      0.0      0.0      0.0   3000.0   3000.0   3000.0   6000.0   6000.0

LABOUR        13800.0  13800.0  20600.0  20600.0  27500.0  34500.0  41000.0  48000.0  55000.0  55000.0  68600.0  82400.0  82400.0

SUPER.LAB      9000.0   9000.0   9000.0   9000.0   9000.0  18000.0  18000.0  18000.0  18000.0  18000.0  18000.0  27000.0  27000.0

MATERIALS       553.2   1553.8   2842.9   4364.3   6085.7   7985.3  12258.9  17094.1  22429.9  28221.3  34433.9  48015.5  63003.1

SERVICES        412.0    546.0    680.0    814.0    948.0   1082.0   1350.0   1618.0   1886.0   2154.0   2422.0   2958.0   3494.0

BUILD.MT        371.0    771.0   1171.0   1571.0   1971.0   2371.0   3171.0   3971.0   4771.0   5571.0   6371.0   7971.0   9571.0

ADMIN          3893.0   5258.0   6623.0   7988.0   9353.0  10718.0  13448.0  16178.0  18908.0  21638.0  24368.0  29828.0  35288.0

RENT           3169.9   4211.7   4973.5   5596.1   6132.2   6608.2   7435.4   8147.8   8780.2   9353.0   9879.3  10825.8  11666.1

RATES          2058.3   2734.9   3229.5   3633.8   3981.9   4291.0   4828.2   5290.8   5701.4   6073.4   6415.2   7029.8   7575.4

*********************************************************************************************************************************

SUM.TOTAL     45611.   54181.   69378.   77778.   93135.  117672.  148513.  173226.  205100.  229540.  261923.  332272.  375845.
(EXCLUDING CAPITAL CHARGES)


CP.CHARGE 141936.4 172838.8 197754.9 231513.7 256403.0 287232.9 339899.3 404448.9 460010.4 521514.0 571241.4 682339.3 793551.0

*********************************************************************************************************************************

SUM.TOTAL    187547.  227020.  267133.  309292.  349538.  404904.  488412.  577675.  665111.  751054.  833165. 1014611. 1169396.
(INCLUDING CAPITAL CHARGES)
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******************************************************************************

BASE CASE COSTS AT SELECTED DAILY TONNEAGES FOR LANDFILL-RELATED DISPOSAL METHODS

******************************************************************************


                         WIRE BALING AND TRANSFER (APRON STORAGE ASSUMED)
                         ************************************************

CAPITAL COSTS    (RANGE 50 TO 320 TONNES PER DAY)

T/D              50.       60.       75.       80.      100.      125.      150.      175.      200.      225.      250.      300.      320.
RATED CAP        15.       15.       23.       23.       23.       23.       30.       30.       30.       45.       45.       70.       70.
**************************************************************************************************************************************

SURVEY      12316.0   12316.0   39572.0   39572.0   39572.0   39572.0   63421.0   63421.0   63421.0  114526.0  114526.0  199701.0  199701.0

BUILDINGS  180000.0  180000.0  198306.0  232176.0  367656.0  537006.0  706356.0  875706.01045056.01214406.01383756.01722456.01857936.0

PREPARE      8110.0    8304.5    8548.9    8620.9    8874.7    9135.9    9355.0    9544.4    9711.5    9861.4    9997.4   10237.1   10323.4

BALER       96085.0   96085.0  140533.0  140533.0  140533.0  140533.0  179425.0  179425.0  179425.0  262765.0  262765.0  401665.0  401665.0

ANCILLARY   19807.0   38857.0   67432.0   76957.0  115057.0  162682.0  210307.0  257932.0  305557.0  353182.0  400807.0  496057.0  534157.0

MOBILE PLANT - LOADING SHOVEL
            30000.0   30000.0   30000.0   40000.0   40000.0   40000.0   40000.0   50000.0   50000.0   50000.0   60000.0   60000.0   80000.0

MOBILE PLANT - SLAVE VEHICLE
                0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0   20000.0   20000.0

**************************************************************************************************************************************

SUM.TOTAL   346318.   365563.   484392.   537859.   711693.   928929.  1208864.  1436028.  1653171.  2004740.  2231852.  2910116.  3103783.

CAPITAL COSTS AMORTISED OVER 10Y AT 14%PA - BALER AND ANCILLARY EQUIPMENT
   "      "       "       "  20Y AT 14%PA - BUILDINGS AND SITE PREPARATIONS
   "      "       "       "   5Y AT 14%PA - LOADING SHOVELS AND SLAVE VEHICLES
```

<u>Wire-tied Baling</u>

```
OPERATING COSTS    (RANGE 50 TO 320 TONNES PER DAY)

T/D              50.       60.       75.       80.      100.      125.      150.      175.      200.      225.      250.      300.      320.
************************************************************************************************************************************

BALER MT     11655.0   11963.0   12425.0   12579.0   13195.0   13965.0   14735.0   15505.0   16275.0   17045.0   17815.0   19355.0   19971.0

ELECTRIC      4172.0    5043.0    6349.5    6785.0    8527.0   10704.5   12882.0   15059.5   17237.0   19780.5   21958.0   26313.0   28055.0

VEH.FUEL      1349.5    1443.8    1585.3    1632.4    1821.0    2056.8    2292.5    2528.3    2764.0    2999.8    4113.5    4585.0    4773.6

V.MT.LAB      2155.0    2295.0    2505.0    2575.0    2855.0    3205.0    3555.0    3905.0    4255.0    4605.0    6410.0    7110.0    7390.0

V.SPARES       680.0     759.2     878.0     917.6    1076.0    1274.0    1472.0    1670.0    1868.0    2066.0    2548.0    2944.0    3102.4

V.TYRES       1413.5    1491.0    1607.3    1646.0    1801.0    1994.8    2188.5    2382.3    2576.0    2769.8    3989.5    4377.0    4532.0

VEH.LIC        150.0     150.0     150.0     150.0     150.0     150.0     150.0     150.0     150.0     150.0     300.0     300.0     300.0

SLAVE VEHICLE (COMBINED OPERATING COST)
                 0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0    3000.0    3000.0

LABOUR       27500.0   27500.0   27500.0   27500.0   27500.0   27500.0   27500.0   34500.0   34500.0   41000.0   41000.0   55000.0   68600.0

SUPER.LAB     9000.0    9000.0    9000.0    9000.0    9000.0    9000.0    9000.0    9000.0    9000.0   18000.0   18000.0   18000.0   18000.0

MATERIALS      900.0     900.0     995.5    1474.0    3388.0    5780.5    8173.0   10565.5   12958.0   15350.5   17743.0   22528.0   24442.0

BALE WIRE     6790.0    7940.0    9665.0   10240.0   12540.0   15415.0   18290.0   21165.0   24040.0   26915.0   29790.0   35540.0   37840.0

SERVICES        60.0     166.0     325.0     378.0     590.0     855.0    1120.0    1385.0    1650.0    1915.0    2180.0    2710.0    2922.0

BUILD.MT       400.0     400.0     400.0     400.0     400.0     700.0     700.0     700.0     700.0    1000.0    1000.0    1000.0    1300.0

ADMIN         5967.0    6671.0    7727.0    8079.0    9487.0   11247.0   13007.0   14767.0   16527.0   18287.0   20047.0   23567.0   24975.0

RENT          4211.7    4538.6    4973.5    5106.8    5596.1    6132.2    6608.2    7039.3    7435.4    7803.3    8147.8    8780.2    9015.6

RATES         2734.9    2947.2    3229.5    3316.1    3633.8    3981.9    4291.0    4571.0    4828.2    5067.1    5290.8    5701.4    5854.3

************************************************************************************************************************************

SUM.TOTAL   79138.6   83207.8   89315.5   91778.9 101559.9 113961.7 125964.2 144892.8 156763.6 184753.9 200332.5 240810.6 264072.9
(EXCLUDING CAPITAL CHARGES)


CP.CHARGE   59358.5   63040.1   79840.4   89704.1 117502.3 152241.5 194430.6 232071.8 266796.9 317496.8 355130.0 457020.6 490619.1

************************************************************************************************************************************

SUM.TOTAL 138497.2 146247.9 169155.9 181483.0 219062.2 266203.2 320394.8 376964.6 423560.6 502250.7 555462.5 697831.1 754692.0
(INCLUDING CAPITAL CHARGES)
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APPENDIX 8G

Transfer:

Base Case Percentage Values

Compaction without Storage

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PERCENTAGE VALUES - CAPITAL COSTS

T/D             25.     30.     40.     50.     60.     75.     80.     90.    100.    125.    150.    175.    200.
RATED CAP        5.      5.     11.     11.     11.     15.     15.     15.     16.     22.     22.     27.     33.
**********************************************************************************************************************

SURVEY          6.6     6.8     6.2     6.5     6.8     6.7     6.4     6.6     6.7     6.6     7.0     6.9     6.9

BUILDINGS      36.8    41.9    42.6    48.3    52.9    54.6    52.2    55.0    56.7    58.1    61.9    62.7    62.9

COMPACTOR      28.5    25.7    32.6    28.6    25.5    26.6    23.7    22.0    21.4    22.8    20.1    20.8    21.9

PREPARE         9.3     8.6     6.4     5.8     5.3     4.4     4.0     3.7     3.5     2.9     2.6     2.3     2.0

ANCILLARY      18.9    17.0    12.2    10.7     9.6     7.7    13.8    12.8    11.8     9.5     8.4     7.2     6.3

**********************************************************************************************************************

SUM.TOTAL     100.0   100.0   100.0   100.0   100.0   100.0   100.0   100.0   100.0   100.0   100.0   100.0   100.0
```

Compaction without Storage

```
PERCENTAGE VALUES - OPERATING COSTS
(INCLUDING CAPITAL CHARGES)

T/D          25.    30.    40.    50.    60.    75.    80.    90.   100.   125.   150.   175.   200.
*****************************************************************************************************

COMPCT MT    3.0    3.2    3.2    3.5    3.3    3.5    3.4    3.6    3.7    3.7    4.0    3.8    4.0

ELECTRIC     7.3    7.5    7.3    7.5    6.6    6.6    6.3    6.4    6.4    5.8    5.8    5.3    5.1

LABOUR      32.7   31.1   26.7   24.8   30.6   27.4   25.7   24.6   23.4   24.6   22.8   25.2   23.2

SUPER.LAB    6.4    6.0    5.2    4.8    5.9    5.3    5.0    4.8    4.6    5.0    4.6    4.9    4.5

MATERIALS    0.3    0.3    0.4    0.4    0.4    0.5    0.5    0.5    0.6    0.6    0.6    0.6    0.7

SERVICES     0.4    0.4    0.3    0.3    0.3    0.2    0.4    0.4    0.3    0.3    0.3    0.3    0.3

BUILD.MT     0.9    0.9    0.8    0.7    0.6    0.5    0.9    0.8    0.8    0.7    0.6    0.7    0.7

ADMIN        6.5    6.5    6.0    6.0    5.3    5.3    5.1    5.2    5.2    4.9    5.0    4.7    4.8

RENT         7.5    7.7    7.4    7.6    6.7    6.6    6.3    6.4    6.3    5.7    5.7    5.1    5.0

RATES        4.9    5.0    4.8    4.9    4.4    4.3    4.1    4.1    4.1    3.7    3.7    3.3    3.2


CP.CHARGE   30.2   31.4   37.9   39.5   35.9   39.8   42.3   43.3   44.6   45.1   46.8   45.9   48.5

*****************************************************************************************************

SUM.TOTAL  100.0  100.0  100.0  100.0  100.0  100.0  100.0  100.0  100.0  100.0  100.0  100.0  100.0
```

Compaction with Apron Storage

```
PERCENTAGE VALUES - CAPITAL COSTS

T/D             25.     30.     40.     50.     60.     75.     80.     90.    100.    125.    150.    175.    200.
RATED CAP        5.      5.     11.     11.     11.     11.     11.     15.     15.     16.     22.     22.     30.
**********************************************************************************************************************

SURVEY          6.4     6.5     6.1     6.3     6.6     6.8     6.6     6.5     6.6     6.6     6.5     6.6     6.5

BUILDINGS      28.1    32.8    35.9    41.6    46.2    51.7    51.1    51.6    54.1    56.2    57.7    59.7    59.8

PREPARE         6.5     6.1     4.9     4.5     4.2     3.8     3.5     3.2     3.0     2.5     2.2     2.0     1.8

COMPACTOR      19.8    18.3    25.0    22.4    20.2    17.7    16.3    18.7    17.6    15.2    17.0    15.0    17.3

ANCILLARY      13.1    12.1     9.4     8.4     7.6     6.6     6.1     5.5     5.1     8.4     7.1     6.3     5.5

MOBILE PT      26.2    24.2    18.7    16.8    15.2    13.3    16.3    14.5    13.6    11.2     9.5    10.4     9.1

**********************************************************************************************************************

SUM.TOTAL     100.0   100.0   100.0   100.0   100.0   100.0   100.0   100.0   100.0   100.0   100.0   100.0   100.0
```

Compaction with Apron Storage

```
PERCENTAGE VALUES - OPERATING COSTS
(INCLUDING CAPITAL CHARGES)
T/D           25.    30.    40.    50.    60.    75.    80.    90.   100.   125.   150.   175.   200.
*******************************************************************************************************

COMPCT MT     2.0    2.1    2.2    2.4    2.4    2.6    2.6    2.7    2.9    2.9    3.1    3.1    3.2
ELECTRIC      4.7    4.9    5.0    5.2    4.9    5.0    4.9    4.9    4.9    4.6    4.5    4.2    4.1
DRIVER       11.6   11.1    9.9    9.4    8.1    7.6    7.2    6.8    6.5    5.5    5.0    4.4    4.0
VEH.FUEL      1.7    1.7    1.7    1.7    1.6    1.6    1.6    1.6    1.6    1.5    1.5    1.5    1.5
V.MT.LAB      2.8    2.8    2.7    2.7    2.5    2.5    2.5    2.5    2.5    2.4    2.4    2.3    2.3
V.SPARES      0.7    0.8    0.8    0.9    0.8    0.9    0.9    0.9    0.9    0.9    1.0    1.0    1.0
V.TYRES       1.9    1.9    1.8    1.8    1.6    1.6    1.6    1.6    1.6    1.5    1.5    1.4    1.4
VEH.LIC       0.2    0.2    0.2    0.2    0.2    0.2    0.1    0.1    0.1    0.1    0.1    0.1    0.1
LABOUR       21.3   20.5   18.3   17.3   22.3   20.9   19.9   18.7   18.0   19.5   17.7   20.1   18.5
SUPER.LAB     4.1    4.0    3.6    3.4    4.3    4.1    3.9    3.6    3.5    3.9    3.6    3.9    3.6
MATERIALS     0.2    0.2    0.3    0.3    0.3    0.4    0.4    0.4    0.4    0.5    0.5    0.5    0.5
SERVICES      0.3    0.3    0.2    0.2    0.2    0.2    0.2    0.2    0.1    0.2    0.2    0.2    0.2
BUILD.MT      0.6    0.6    0.5    0.5    0.4    0.4    0.4    0.4    0.3    0.5    0.5    0.4    0.4
ADMIN         6.1    6.1    5.8    5.8    5.3    5.4    5.2    5.2    5.2    4.9    4.9    4.6    4.6
RENT          4.9    5.1    5.1    5.3    4.9    5.0    4.9    4.8    4.9    4.5    4.4    4.1    4.0
RATES         3.2    3.3    3.3    3.4    3.2    3.3    3.2    3.1    3.2    2.9    2.9    2.7    2.6

CP.CHARGE    33.8   34.5   38.7   39.7   37.0   38.5   40.7   42.6   43.3   43.8   46.3   45.7   48.0
*******************************************************************************************************
SUM.TOTAL   100.0  100.0  100.0  100.0  100.0  100.0  100.0  100.0  100.0  100.0  100.0  100.0  100.0
```

```
PERCENTAGE VALUES - CAPITAL COSTS

T/D          25.      30.      40.      50.      60.      75.      80.      90.     100.     125.     150.     175.     200.
RATED CAP     5.       5.      11.      11.      11.      11.      11.      15.      15.      16.      22.      22.      30.
*****************************************************************************************************************************

SURVEY       5.8      6.0      6.1      6.5      6.9      7.3      7.5      7.6      7.8      5.8      6.1      6.5      6.8

BUILDINGS   10.0     12.2     15.6     19.1     22.3     26.6     27.9     29.6     31.8     25.4     28.3     31.5     33.4

PREPARE      2.3      2.3      2.1      2.1      2.0      2.0      1.9      1.8      1.8      1.2      1.1      1.1      1.0

COMPACTOR    7.0      6.8     10.8     10.3      9.8      9.1      8.9     10.8     10.3      6.9      8.4      7.9      9.7

ANCILLARY    4.7      4.5      4.1      3.9      3.7      3.4      3.3      3.1      3.0      3.8      3.5      3.3      3.1

O/H CRANE OR CONVEYOR SYSTEM
             8.1      7.8      7.0      6.7      6.4      5.9      5.8      5.4      5.2      6.6      6.1      5.7      5.3

BUNKER      62.2     60.3     54.2     51.4     48.9     45.6     44.6     41.7     40.0     50.5     46.5     44.0     40.8

*****************************************************************************************************************************

SUM.TOTAL  100.0    100.0    100.0    100.0    100.0    100.0    100.0    100.0    100.0    100.0    100.0    100.0    100.0
```

Compaction with Bunker Storage

```
PERCENTAGE VALUES - OPERATING COSTS
(INCLUDING CAPITAL CHARGES)

T/D           25.     30.     40.     50.     60.     75.     80.     90.    100.    125.    150.    175.    200.
***************************************************************************************************************

COMPCT MT     1.4     1.5     1.7     1.9     1.9     2.1     2.2     2.3     2.4     1.9     2.1     2.2     2.4

ELECTRIC      3.4     3.6     3.8     4.0     3.8     4.0     4.1     4.1     4.1     3.1     3.1     3.1     3.1

LABOUR       15.4    15.0    13.8    13.2    17.6    16.8    16.5    15.7    15.2    13.1    12.3    14.6    13.8

SUPER.LAB     3.0     2.9     2.7     2.6     3.4     3.3     3.2     3.1     3.0     2.6     2.5     2.8     2.7

MATERIALS     0.1     0.2     0.2     0.2     0.3     0.3     0.3     0.3     0.4     0.3     0.3     0.4     0.4

SERVICES      0.2     0.2     0.2     0.2     0.1     0.1     0.1     0.1     0.1     0.1     0.1     0.1     0.1

BUILD.MT      0.4     0.4     0.4     0.4     0.3     0.3     0.3     0.3     0.3     0.3     0.3     0.3     0.3

GRAB ELEC     2.8     2.8     2.7     2.7     2.5     2.5     2.6     2.5     2.6     3.0     2.9     2.8     2.8

GRAB MT       0.6     0.6     0.5     0.5     0.9     0.8     0.8     0.8     0.8     1.0     1.0     1.3     1.2

GRAB OP       8.4     8.2     7.5     7.2     6.4     6.1     6.0     5.7     5.5     7.4     7.0     6.4     6.0

ADMIN         4.5     4.5     4.5     4.7     4.5     4.7     4.7     4.8     4.9     3.7     3.9     4.0     4.1

RENT          3.5     3.7     3.8     4.0     3.9     4.0     4.1     4.1     4.1     3.0     3.1     3.0     3.0

RATES         2.3     2.4     2.5     2.6     2.5     2.6     2.6     2.6     2.7     2.0     2.0     1.9     1.9


CP.CHARGE    54.0    54.0    55.7    55.8    51.8    52.3    52.5    53.6    53.9    58.4    59.4    57.1    58.2

***************************************************************************************************************

SUM.TOTAL   100.0   100.0   100.0   100.0   100.0   100.0   100.0   100.0   100.0   100.0   100.0   100.0   100.0
```

```
PERCENTAGE VALUES - CAPITAL COSTS

T/D             25.     50.     75.    100.    125.    150.    200.    250.    300.    350.    400.    500.    600.
RATED CAP        9.      9.      9.     15.     15.     15.     18.     18.     30.     30.     35.     35.     40.
******************************************************************************************************************

SURVEY          6.7     6.9     7.1     6.6     6.8     6.9     6.8     6.9     6.5     6.6     6.6     6.7     6.7

BUILDINGS      45.5    53.6    59.2    58.4    62.0    64.8    67.1    69.8    67.5    68.9    69.8    71.6    72.7

PREPARE         2.2     2.0     1.8     1.5     1.4     1.3     1.1     0.9     0.8     0.7     0.7     0.6     0.5

PULVERISER
               22.6    18.6    15.8    17.1    15.3    13.8    12.7    10.9    13.0    11.6    11.7     9.8     9.3

ANCILLARY      13.9    11.5     9.7     9.6     8.6     7.8     6.8     5.8     5.9     5.2     5.0     4.2     3.8

MOBILE PLANT - LOADING SHOVEL
                9.0     7.4     6.3     6.8     6.0     5.5     5.5     5.7     4.7     5.5     5.0     5.2     5.3

MOBILE PLANT - SLAVE VEHICLE
                0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     1.6     1.4     1.2     2.1     1.8

******************************************************************************************************************

SUM.TOTAL      100.    100.    100.    100.    100.    100.    100.    100.    100.    100.    100.    100.    100.
```

```
 PERCENTAGE VALUES - OPERATING COSTS
(INCLUDING CAPITAL CHARGES)

T/D             25.      50.      75.     100.     125.     150.     200.     250.     300.     350.     400.     500.     600.
****************************************************************************************************************************

PULV.MT         6.0      7.8      9.5      9.4     10.3     10.1     10.9     10.9     10.7     10.7     11.0     11.1     11.0

ELECTRIC        8.0      7.8      8.4      7.9      8.3      8.1      8.6      8.6      8.4      8.5      8.8      9.1      9.2

VEH.FUEL        1.0      0.9      0.9      0.9      0.9      0.8      0.9      0.9      1.0      1.0      1.0      1.0      1.1

V.MT.LAB        1.6      1.5      1.5      1.3      1.4      1.3      1.3      1.3      1.6      1.5      1.5      1.5      1.7

V.SPARES        0.4      0.5      0.5      0.5      0.5      0.5      0.6      0.6      0.7      0.7      0.7      0.7      0.7

V.TYRES         1.1      1.0      1.0      0.8      0.9      0.8      0.8      0.8      1.0      0.9      0.9      0.9      1.0

VEH.LIC         0.1      0.1      0.1      0.1      0.1      0.1      0.0      0.0      0.1      0.1      0.1      0.0      0.1

SLAVE VEHICLE (COMBINED OPERATING COST)
                0.0      0.0      0.0      0.0      0.0      0.0      0.0      0.0      0.7      0.6      0.5      0.9      0.8

LABOUR         12.6     18.8     16.4     19.3     17.6     22.6     19.4     21.7     18.2     18.9     17.5     16.9     16.3

SUPER.LAB       8.2      6.1      5.4      4.2      3.9      3.3      2.8      2.4      4.0      3.5      3.3      2.8      3.6

MATERIALS       0.1      0.2      0.2      0.2      0.3      0.3      0.3      0.3      0.3      0.3      0.4      0.4      0.4

SERVICES        0.4      0.4      0.4      0.4      0.4      0.4      0.4      0.4      0.4      0.4      0.4      0.5      0.5

BUILD.MT        0.4      0.3      0.2      0.2      0.3      0.3      0.2      0.3      0.2      0.3      0.2      0.2      0.2

ADMIN           4.4      5.0      5.6      5.3      5.6      5.3      5.4      5.2      4.9      4.8      4.8      4.6      4.4

RENT            2.9      2.9      3.0      2.6      2.6      2.4      2.3      2.1      1.9      1.8      1.8      1.7      1.5

RATES           1.9      1.9      1.9      1.7      1.7      1.6      1.5      1.4      1.3      1.2      1.2      1.1      1.0


CP.CHARGE      50.9     44.9     45.0     45.0     45.3     42.2     44.4     43.1     44.7     44.7     45.9     46.6     46.5

****************************************************************************************************************************

SUM.TOTAL     100.0    100.0    100.0    100.0    100.0    100.0    100.0    100.0    100.0    100.0    100.0    100.0    100.0
```

Wet Pulverisation

```
PERCENTAGE VALUES - CAPITAL COSTS

T/D              25.     50.     75.    100.    125.    150.    200.    250.    300.    350.    400.    500.    600.
RATED CAP         5.     10.     10.     15.     15.     20.     20.     30.     30.     35.     35.     35.     40.
***********************************************************************************************************************

SURVEY           6.6     6.5     6.6     6.4     6.5     6.4     6.5     6.4     6.4     6.4     6.4     6.4     6.5

BUILDINGS       31.0    36.6    41.4    43.7    46.6    48.1    51.6    52.7    54.5    55.4    56.9    58.6    59.7

PREPARE          0.9     0.8     0.7     0.6     0.6     0.5     0.5     0.4     0.4     0.3     0.3     0.3     0.2

PULVERISER
                50.9    44.6    41.4    37.8    36.1    34.1    32.0    29.7    28.5    27.4    26.8    25.8    24.9

ANCILLARY        7.0     8.7     7.5     8.6     7.7     8.5     7.2     8.5     7.4     7.5     6.8     5.7     5.5

MOBILE PLANT - LOADING SHOVEL
                 3.6     2.9     2.5     2.8     2.5     2.3     2.4     2.4     2.1     2.5     2.2     2.3     2.4

MOBILE PLANT - SLAVE VEHICLE
                 0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.7     0.6     0.6     0.9     0.8

***********************************************************************************************************************

SUM.TOTAL       100.    100.    100.    100.    100.    100.    100.    100.    100.    100.    100.    100.    100.
```

```
PERCENTAGE VALUES - OPERATING COSTS
(INCLUDING CAPITAL CHARGES)

T/D          25.    50.    75.    100.   125.   150.   200.   250.   300.   350.   400.   500.   600.
**********************************************************************************************************

PULV.MT      0.8    2.0    2.8    3.4    3.9    4.1    4.6    4.9    5.2    5.4    5.5    5.7    6.0

ELECTRIC     3.2    2.6    2.2    1.9    1.7    1.5    2.7    2.3    2.0    2.5    2.3    2.5    2.1

VEH.FUEL     0.6    0.6    0.6    0.6    0.6    0.6    0.6    0.6    0.7    0.7    0.7    0.6    0.7

V.MT.LAB     1.0    0.9    0.9    0.9    0.9    0.9    0.9    0.9    1.1    1.0    1.0    1.0    1.1

V.SPARES     0.3    0.3    0.3    0.3    0.4    0.4    0.4    0.4    0.4    0.4    0.4    0.4    0.5

V.TYRES      0.7    0.6    0.6    0.6    0.6    0.5    0.5    0.5    0.7    0.6    0.6    0.6    0.7

VEH.LIC      0.1    0.1    0.1    0.0    0.0    0.0    0.0    0.0    0.0    0.0    0.0    0.0    0.0

SLAVE VEHICLE (COMBINED OPERATING COST)
             0.0    0.0    0.0    0.0    0.0    0.0    0.0    0.0    0.5    0.4    0.4    0.6    0.5

LABOUR       7.4    6.1    7.7    6.7    7.9    8.5    8.4    8.3    8.3    7.3    8.2    8.1    7.0

SUPER.LAB    4.8    4.0    3.4    2.9    2.6    4.4    3.7    3.1    2.7    2.4    2.2    2.7    2.3

MATERIALS    0.3    0.7    1.1    1.4    1.7    2.0    2.5    3.0    3.4    3.8    4.1    4.7    5.4

SERVICES     0.2    0.2    0.3    0.3    0.3    0.3    0.3    0.3    0.3    0.3    0.3    0.3    0.3

BUILD.MT     0.2    0.3    0.4    0.5    0.6    0.6    0.6    0.7    0.7    0.7    0.8    0.8    0.8

ADMIN        2.1    2.3    2.5    2.6    2.7    2.6    2.8    2.8    2.8    2.9    2.9    2.9    3.0

RENT         1.7    1.9    1.9    1.8    1.8    1.6    1.5    1.4    1.3    1.2    1.2    1.1    1.0

RATES        1.1    1.2    1.2    1.2    1.1    1.1    1.0    0.9    0.9    0.8    0.8    0.7    0.6


CP.CHARGE   75.7   76.1   74.0   74.9   73.4   70.9   69.6   70.0   69.2   69.4   68.6   67.3   67.9

**********************************************************************************************************

SUM.TOTAL   100.   100.   100.   100.   100.   100.   100.   100.   100.   100.   100.   100.   100.
```

Wire-tied Baling

```
PERCENTAGE VALUES - CAPITAL COSTS

T/D              50.       60.       75.       80.      100.      125.      150.      175.      200.      225.      250.      300.      320.
RATED CAP        15.       15.       23.       23.       23.       23.       30.       30.       30.       45.       45.       70.       70.
*****************************************************************************************************************************************

SURVEY           3.6       3.4       8.2       7.4       5.6       4.3       5.2       4.4       3.8       5.7       5.1       6.9       6.4

BUILDINGS       52.0      49.2      40.9      43.2      51.7      57.8      58.4      61.0      63.2      60.6      62.0      59.2      59.9

PREPARE          2.3       2.3       1.8       1.6       1.2       1.0       0.8       0.7       0.6       0.5       0.4       0.4       0.3

BALER           27.7      26.3      29.0      26.1      19.7      15.1      14.8      12.5      10.9      13.1      11.8      13.8      12.9

ANCILLARY        5.7      10.6      13.9      14.3      16.2      17.5      17.4      18.0      18.5      17.6      18.0      17.0      17.2

MOBILE PLANT  -  LOADING SHOVEL
                 8.7       8.2       6.2       7.4       5.6       4.3       3.3       3.5       3.0       2.5       2.7       2.1       2.6

MOBILE PLANT  -  SLAVE VEHICLE
                 0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.7       0.6

*****************************************************************************************************************************************

SUM.TOTAL       100.      100.      100.      100.      100.      100.      100.      100.      100.      100.      100.      100.      100.
```

Wire-tied Baling

```
PERCENTAGE VALUES - OPERATING COSTS
(INCLUDING CAPITAL CHARGES)

T/D            50.     60.     75.     80.    100.    125.    150.    175.    200.    225.    250.    300.    320.
*****************************************************************************************************************

BALER MT       8.4     8.2     7.3     6.9     6.0     5.2     4.6     4.1     3.8     3.4     3.2     2.8     2.6

ELECTRIC       3.0     3.4     3.8     3.7     3.9     4.0     4.0     4.0     4.1     3.9     4.0     3.8     3.7

VEH.FUEL       1.0     1.0     0.9     0.9     0.8     0.8     0.7     0.7     0.7     0.6     0.7     0.7     0.6

V.MT.LAB       1.6     1.6     1.5     1.4     1.3     1.2     1.1     1.0     1.0     0.9     1.2     1.0     1.0

V.SPARES       0.5     0.5     0.5     0.5     0.5     0.5     0.5     0.4     0.4     0.4     0.5     0.4     0.4

V.TYRES        1.0     1.0     1.0     0.9     0.8     0.7     0.7     0.6     0.6     0.6     0.7     0.6     0.6

VEH.LIC        0.1     0.1     0.1     0.1     0.1     0.1     0.0     0.0     0.0     0.0     0.1     0.0     0.0

SLAVE VEHICLE (COMBINED OPERATING COST)
               0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.4     0.4

LABOUR        19.9    18.8    16.3    15.2    12.6    10.3     8.6     9.2     8.1     8.2     7.4     7.9     9.1

SUPER.LAB      6.5     6.2     5.3     5.0     4.1     3.4     2.8     2.4     2.1     3.6     3.2     2.6     2.4

MATERIALS      0.6     0.6     0.6     0.8     1.5     2.2     2.6     2.8     3.1     3.1     3.2     3.2     3.2

BALE WIRE      4.9     5.4     5.7     5.6     5.7     5.8     5.7     5.6     5.7     5.4     5.4     5.1     5.0

SERVICES       0.0     0.1     0.2     0.2     0.3     0.3     0.3     0.4     0.4     0.4     0.4     0.4     0.4

BUILD.MT       0.3     0.3     0.2     0.2     0.2     0.3     0.2     0.2     0.2     0.2     0.2     0.1     0.2

ADMIN          4.3     4.6     4.6     4.5     4.3     4.2     4.1     3.9     3.9     3.6     3.6     3.4     3.3

RENT           3.0     3.1     2.9     2.8     2.6     2.3     2.1     1.9     1.8     1.6     1.5     1.3     1.2

RATES          2.0     2.0     1.9     1.8     1.7     1.5     1.3     1.2     1.1     1.0     1.0     0.8     0.8


CP.CHARGE     42.9    43.1    47.2    49.4    53.6    57.2    60.7    61.6    63.0    63.2    63.9    65.5    65.0

*****************************************************************************************************************

SUM.TOTAL    100.0   100.0   100.0   100.0   100.0   100.0   100.0   100.0   100.0   100.0   100.0   100.0   100.0
```

APPENDIX 8H

Transfer:

Base Case Relative Sensitivities

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RELATIVE SENSITIVITIES (RS) - CAPITAL COSTS
**********************************************

SENSITIVITY RANGES CONSIDERED
  X OR / 2.00 : SURVEY
  X OR / 1.50  : BUILDINGS, COMPACTION AND ANCILLARY EQUIPMENT AND SITE PREPARATIONS

                                                RS VALUES
LINEAR FUNCTIONS PRODUCE A CONSTANT RS VALUE FOR THE ENTIRE SENSITIVITY RANGE
CURVILINEAR FUNCTIONS DO NOT, INSTEAD SELECTED RS VALUES ARE GIVEN


T/D             25.      30.      40.      50.      60.      75.      80.      90.     100.     125.     150.     175.     200.

RATED CAP        5.       5.      11.      11.      11.      15.      15.      15.      16.      22.      22.      27.      33.
**************************************************************************************************************************************
SURVEY         0.065    0.068    0.061    0.065    0.068    0.067    0.063    0.065    0.066    0.066    0.069    0.069    0.068

BUILDINGS      0.355    0.402    0.408    0.461    0.502    0.518    0.496    0.521    0.537    0.549    0.583    0.590    0.591

COMPACTOR      0.277    0.250    0.316    0.278    0.248    0.259    0.231    0.215    0.209    0.223    0.197    0.204    0.214

ANCILLARY      0.185    0.167    0.121    0.106    0.095    0.077    0.136    0.126    0.116    0.094    0.083    0.072    0.063

PREPARE
 1.10          0.092    0.085    0.064    0.058    0.053    0.044    0.039    0.037    0.035    0.029    0.026    0.023    0.020
 1.25          0.091    0.084    0.063    0.057    0.052    0.044    0.039    0.037    0.035    0.029    0.026    0.023    0.020
 1.50          0.089    0.083    0.062    0.056    0.052    0.043    0.039    0.037    0.034    0.029    0.026    0.023    0.020
```

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RELATIVE SENSITIVITIES (RS) - OPERATING COSTS
*********************************************************

SENSITIVITY RANGES CONSIDERED
  X OR / 2.00 : COMPACTOR MAINTENANCE, BUILDING MAINT, SITE RENT
  X OR / 1.50 :  MANUAL & SUPERVISORY LABOUR, DEPT. ADMIN., SITE RATES, SERVICES, CAPITAL CHARGES
  X OR / 1.25 : COMPACTOR ELECTRICITY, MATERIALS (EXCLUDING COVER)

                                                  RS VALUES
SEE COMMENT IN CAPITAL COST SECTION


T/D              25.      30.      40.      50.      60.      75.      80.      90.     100.     125.     150.     175.     200.
*********************************************************************************************************************************

COMPCT MT       0.030    0.032    0.032    0.035    0.033    0.034    0.034    0.036    0.037    0.037    0.040    0.038    0.040

ELECTRIC
 1.10           0.072    0.074    0.072    0.074    0.066    0.065    0.063    0.063    0.063    0.057    0.058    0.052    0.051
 1.15           0.072    0.074    0.072    0.074    0.066    0.065    0.063    0.063    0.063    0.057    0.058    0.052    0.051
 1.25           0.071    0.073    0.071    0.073    0.065    0.065    0.062    0.063    0.063    0.057    0.057    0.052    0.051

LABOUR          0.316    0.302    0.260    0.242    0.297    0.267    0.250    0.240    0.229    0.241    0.223    0.246    0.227

SUPER.LAB       0.063    0.060    0.052    0.048    0.059    0.053    0.050    0.048    0.045    0.050    0.046    0.049    0.045

MATERIALS       0.003    0.003    0.004    0.004    0.004    0.005    0.005    0.005    0.006    0.006    0.006    0.006    0.007

SERVICES        0.004    0.004    0.003    0.003    0.003    0.002    0.004    0.004    0.003    0.003    0.003    0.003    0.003

BUILD.MT        0.009    0.009    0.008    0.007    0.006    0.005    0.009    0.008    0.008    0.007    0.006    0.007    0.007

ADMIN           0.065    0.064    0.060    0.060    0.053    0.052    0.051    0.051    0.052    0.048    0.050    0.047    0.047

RENT
 1.10           0.074    0.076    0.074    0.075    0.067    0.065    0.063    0.063    0.063    0.057    0.057    0.051    0.050
 1.50           0.072    0.074    0.072    0.073    0.065    0.064    0.061    0.062    0.061    0.055    0.055    0.050    0.049
 2.00           0.070    0.071    0.069    0.070    0.063    0.062    0.060    0.060    0.060    0.054    0.054    0.049    0.048

RATES
 1.10           0.048    0.050    0.048    0.049    0.043    0.043    0.041    0.041    0.041    0.037    0.037    0.033    0.032
 1.25           0.048    0.049    0.048    0.049    0.043    0.042    0.041    0.041    0.041    0.037    0.037    0.033    0.032
 1.50           0.048    0.049    0.047    0.048    0.043    0.042    0.040    0.040    0.040    0.036    0.036    0.033    0.032

CP.CHARGE       0.293    0.304    0.365    0.380    0.347    0.383    0.406    0.415    0.427    0.432    0.447    0.439    0.463
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RELATIVE SENSITIVITIES (RS) - CAPITAL COSTS
**********************************************

SENSITIVITY RANGES CONSIDERED
  X OR / 2.00 : SURVEY
  X OR / 1.50  : BUILDINGS, COMPACTION AND ANCILLARY EQUIPMENT AND SITEPREPARATIONS
  X OR / 1.25  : MOBILE PLANT

                                   RS VALUES
LINEAR FUNCTIONS PRODUCE A CONSTANT RS VALUE FOR THE ENTIRE SENSITIVITY RANGE
CURVILINEAR FUNCTIONS DO NOT, INSTEAD SELECTED RS VALUES ARE GIVEN


T/D            25.      30.      40.      50.      60.      75.      80.      90.     100.     125.     150.     175.     200.

RATED CAP       5.       5.      11.      11.      11.      11.      11.      15.      15.      16.      22.      22.      30.
*******************************************************************************************************************************
SURVEY        0.063    0.065    0.060    0.063    0.065    0.068    0.066    0.064    0.066    0.065    0.065    0.066    0.065

BUILDINGS     0.273    0.317    0.347    0.399    0.442    0.492    0.486    0.491    0.513    0.532    0.545    0.563    0.564

PREPARE
 1.10         0.064    0.061    0.049    0.045    0.042    0.038    0.035    0.032    0.030    0.025    0.022    0.020    0.018
 1.25         0.064    0.060    0.049    0.045    0.042    0.038    0.035    0.032    0.030    0.025    0.022    0.020    0.018
 1.50         0.063    0.059    0.048    0.044    0.041    0.037    0.035    0.031    0.030    0.025    0.022    0.020    0.018

COMPACTOR     0.194    0.179    0.244    0.219    0.198    0.174    0.161    0.184    0.173    0.150    0.167    0.148    0.170

ANCILLARY     0.129    0.120    0.093    0.083    0.075    0.066    0.061    0.054    0.051    0.083    0.071    0.062    0.054

MOBILE PT     0.255    0.236    0.184    0.165    0.150    0.131    0.161    0.143    0.134    0.110    0.094    0.103    0.090
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SENSITIVITY RANGES CONSIDERED
  X OR / 2.00 : COMPACTOR MAINTENANCE, BUILDING MAINT, SITE RENT AND VEHICLE FUEL
  X OR / 1.50 : DRIVER, VEHICLE MAINTENANCE, MANUAL & SUPERVISORY LABOUR, DEPT. ADMIN., SITE RATES, SERVICES, CAPITAL CHARGES
  X OR / 1.25 : COMPACTOR ELECTRICITY, MATERIALS, VEHICLE SPARES,TYRES AND LICENCES

                                                    RS VALUES
SEE COMMENT IN CAPITAL COST SECTION


T/D            25.      30.      40.      50.      60.      75.      80.      90.     100.     125.     150.     175.     200.
*****************************************************************************************************************************

COMPCT MT     0.020    0.021    0.022    0.024    0.024    0.026    0.026    0.027    0.028    0.029    0.031    0.031    0.032

ELECTRIC
 1.10         0.047    0.049    0.050    0.052    0.048    0.050    0.049    0.048    0.049    0.045    0.045    0.042    0.041
 1.50         0.047    0.049    0.050    0.052    0.048    0.050    0.049    0.048    0.049    0.045    0.045    0.042    0.041
 1.25         0.047    0.049    0.049    0.051    0.048    0.049    0.048    0.048    0.048    0.045    0.045    0.041    0.041

DRIVER        0.114    0.110    0.096    0.093    0.080    0.075    0.071    0.067    0.065    0.055    0.050    0.043    0.040

VEH.FUEL      0.017    0.017    0.017    0.017    0.016    0.016    0.016    0.016    0.016    0.015    0.015    0.015    0.015

V.MT.LAB      0.028    0.028    0.027    0.027    0.025    0.025    0.025    0.024    0.025    0.023    0.024    0.023    0.023

V.SPARES      0.007    0.008    0.008    0.008    0.008    0.009    0.009    0.009    0.009    0.009    0.010    0.010    0.010

V.TYRES       0.019    0.019    0.018    0.018    0.016    0.016    0.016    0.016    0.016    0.015    0.015    0.014    0.014

VEH.LIC       0.002    0.002    0.002    0.002    0.002    0.002    0.001    0.001    0.001    0.001    0.001    0.001    0.001

LABOUR        0.208    0.201    0.180    0.170    0.218    0.204    0.195    0.184    0.177    0.191    0.174    0.197    0.182

SUPER.LAB     0.041    0.040    0.035    0.033    0.043    0.040    0.038    0.036    0.035    0.039    0.036    0.039    0.036

MATERIALS     0.002    0.002    0.003    0.003    0.003    0.004    0.004    0.004    0.004    0.005    0.005    0.005    0.005

SERVICES      0.003    0.003    0.002    0.002    0.002    0.002    0.002    0.002    0.001    0.002    0.002    0.002    0.002

BUILD.MT      0.006    0.006    0.005    0.005    0.004    0.004    0.004    0.004    0.003    0.005    0.005    0.004    0.004

ADMIN         0.061    0.061    0.058    0.058    0.053    0.053    0.052    0.051    0.052    0.049    0.049    0.046    0.046

RENT
 1.10         0.049    0.050    0.051    0.052    0.049    0.050    0.049    0.048    0.048    0.045    0.044    0.041    0.040
 1.50         0.048    0.049    0.050    0.051    0.048    0.049    0.048    0.047    0.048    0.044    0.043    0.040    0.039
 2.00         0.047    0.048    0.048    0.050    0.047    0.048    0.047    0.046    0.046    0.043    0.042    0.039    0.038

RATES
 1.10         0.032    0.033    0.033    0.034    0.032    0.032    0.032    0.031    0.032    0.029    0.029    0.027    0.026
 1.25         0.031    0.033    0.033    0.034    0.032    0.032    0.032    0.031    0.031    0.029    0.028    0.026    0.026
 1.50         0.031    0.032    0.033    0.034    0.031    0.032    0.031    0.031    0.031    0.029    0.028    0.026    0.026

CP.CHARGE     0.327    0.333    0.372    0.382    0.357    0.371    0.391    0.409    0.415    0.419    0.443    0.437    0.458
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RELATIVE SENSITIVITIES (RS) - CAPITAL COSTS
**********************************************

SENSITIVITY RANGES CONSIDERED
  X OR / 2.00 : SURVEY
  X OR / 1.50  : BUILDINGS, COMPACTION AND ANCILLARY EQUIPMENT, BUNKER CONSTRUCTION AND SITEPREPARATIONS
  X OR / 1.25  : GRAB CRANE/CONVEYOR SYSTEM

                                                RS VALUES
LINEAR FUNCTIONS PRODUCE A CONSTANT RS VALUE FOR THE ENTIRE SENSITIVITY RANGE
CURVILINEAR FUNCTIONS DO NOT, INSTEAD SELECTED RS VALUES ARE GIVEN


T/D              25.      30.      40.      50.      60.      75.      80.      90.     100.     125.     150.     175.     200.

RATED CAP         5.       5.      11.      11.      11.      11.      11.      15.      15.      16.      22.      22.      30.
*************************************************************************************************************************************
SURVEY          0.057    0.060    0.061    0.065    0.068    0.073    0.074    0.075    0.077    0.057    0.061    0.065    0.067

BUILDINGS       0.099    0.121    0.153    0.188    0.219    0.259    0.272    0.288    0.308    0.248    0.276    0.305    0.324

PREPARE
 1.10           0.023    0.023    0.021    0.021    0.020    0.019    0.019    0.018    0.018    0.012    0.011    0.010    0.010
 1.25           0.023    0.023    0.021    0.021    0.020    0.019    0.019    0.018    0.018    0.011    0.011    0.010    0.010
 1.50           0.023    0.023    0.021    0.021    0.020    0.019    0.019    0.018    0.018    0.011    0.011    0.010    0.010

COMPACTOR       0.070    0.068    0.107    0.102    0.097    0.090    0.088    0.106    0.102    0.068    0.083    0.078    0.096

ANCILLARY       0.046    0.045    0.040    0.038    0.037    0.034    0.033    0.031    0.030    0.038    0.035    0.033    0.030

O/H CRANE/CONVEYOR SYSTEM
                0.080    0.078    0.070    0.066    0.063    0.059    0.058    0.054    0.052    0.065    0.060    0.057    0.053

BUNKER          0.585    0.569    0.514    0.489    0.467    0.436    0.427    0.400    0.385    0.480    0.445    0.422    0.392
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RELATIVE SENSITIVITIES (RS) - OPERATING COSTS
**************************************************

SENSITIVITY RANGES CONSIDERED
  X OR / 2.00 : SITE RENT, COMPACTOR AND BUILDING MAINTENANCE
   X OR / 1.50 : MANUAL AND SUPERVISORY LABOUR, SITE RATES, SERVICES, DEPT. ADMIN., CAPITAL CHARGES,
GRAB CRANE OPERATORS AND MAINTENANCE
   X OR / 1.25 : MATERIALS, COMPACTOR AND GRAB CRANE ELECTRICITY

                                        RS VALUES

SEE COMMENT IN CAPITAL COST SECTION

T/D            25.     30.     40.     50.     60.     75.     80.     90.    100.    125.    150.    175.    200.
*****************************************************************************************************************

COMPCT MT     0.014   0.015   0.017   0.019   0.019   0.021   0.022   0.023   0.024   0.019   0.021   0.022   0.024

ELECTRIC
 1.10         0.034   0.036   0.038   0.040   0.038   0.046   0.041   0.041   0.041   0.031   0.031   0.030   0.031
 1.15         0.034   0.036   0.037   0.040   0.038   0.040   0.040   0.041   0.041   0.031   0.031   0.030   0.030
 1.25         0.034   0.036   0.037   0.039   0.038   0.040   0.040   0.040   0.041   0.030   0.031   0.030   0.030

LABOUR        0.152   0.148   0.136   0.131   0.173   0.165   0.162   0.155   0.150   0.129   0.121   0.144   0.136

SUPER.LAB     0.030   0.029   0.027   0.026   0.034   0.032   0.032   0.030   0.030   0.026   0.025   0.028   0.027

MATERIALS     0.001   0.002   0.002   0.002   0.003   0.003   0.003   0.003   0.004   0.003   0.003   0.004   0.004

SERVICES      0.002   0.002   0.002   0.002   0.001   0.001   0.001   0.001   0.001   0.001   0.001   0.001   0.001

BUILD.MT      0.004   0.004   0.004   0.004   0.003   0.003   0.003   0.003   0.003   0.003   0.003   0.003   0.003

GRAB ELEC     0.028   0.028   0.027   0.027   0.025   0.025   0.026   0.025   0.026   0.030   0.029   0.028   0.028

GRAB MT       0.006   0.006   0.005   0.005   0.009   0.008   0.008   0.008   0.008   0.010   0.010   0.013   0.012

GRAB OP       0.083   0.081   0.075   0.071   0.064   0.060   0.059   0.057   0.055   0.073   0.069   0.063   0.060

ADMIN         0.044   0.045   0.045   0.047   0.044   0.046   0.047   0.048   0.049   0.037   0.039   0.039   0.041

RENT
 1.10         0.035   0.037   0.038   0.040   0.039   0.040   0.040   0.040   0.041   0.030   0.031   0.030   0.030
 1.50         0.035   0.036   0.038   0.040   0.036   0.039   0.040   0.040   0.040   0.030   0.030   0.029   0.029
 2.00         0.034   0.036   0.037   0.039   0.037   0.039   0.039   0.039   0.040   0.029   0.030   0.029   0.029

RATES
 1.10         0.023   0.024   0.025   0.026   0.025   0.026   0.026   0.026   0.027   0.020   0.020   0.019   0.019
 1.25         0.023   0.024   0.025   0.026   0.025   0.026   0.026   0.026   0.027   0.020   0.020   0.019   0.019
 1.50         0.023   0.024   0.025   0.026   0.025   0.026   0.026   0.026   0.026   0.019   0.020   0.019   0.019

CP.CHARGE     0.512   0.512   0.527   0.529   0.493   0.497   0.499   0.509   0.512   0.551   0.560   0.540   0.550
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RELATIVE SENSITIVITIES (RS) - CAPITAL COSTS
*******************************************

SENSITIVITY RANGES CONSIDERED
  X OR / 2.00 : SURVEY
  X OR / 1.50  : BUILDINGS, PULVERTSER AND ANCILLARY EQUIPMENT, SITE PREPARATIONS
  X OR / 1.25  : LOADING SHOVEL AND SLAVE VEHICLES

                                                RS VALUES
LINEAR FUNCTIONS PRODUCE A CONSTANT RS VALUE FOR THE ENTIRE SENSITIVITY RANGE
CURVILINEAR FUNCTIONS DO NOT, INSTEAD SELECTED RS VALUES ARE GIVEN


T/D             25.      50.      75.     100.     125.     150.     200.     250.     300.     350.     400.     500.     600.

RATED CAP        9.       9.       9.      15.      15.      15.      18.      18.      30.      30.      35.      35.      40.
*****************************************************************************************************************************
SURVEY        0.067    0.069    0.070    0.066    0.067    0.068    0.068    0.069    0.065    0.065    0.066    0.066    0.066

BUILDINGS     0.435    0.508    0.559    0.552    0.583    0.609    0.629    0.652    0.632    0.645    0.652    0.668    0.677

PREPARE
 1.10         0.022    0.020    0.018    0.015    0.014    0.013    0.011    0.009    0.008    0.007    0.007    0.006    0.005
 1.25         0.022    0.020    0.018    0.015    0.014    0.013    0.011    0.009    0.008    0.007    0.007    0.006    0.005
 1.50         0.022    0.020    0.018    0.015    0.014    0.013    0.011    0.009    0.008    0.007    0.007    0.006    0.005

PULVERTSER
              0.221    0.183    0.156    0.168    0.151    0.136    0.125    0.107    0.129    0.114    0.116    0.097    0.092

ANCILLARY
 1.10         0.137    0.113    0.096    0.095    0.085    0.077    0.068    0.058    0.059    0.052    0.050    0.041    0.037
 1.25         0.134    0.111    0.095    0.094    0.084    0.076    0.067    0.057    0.058    0.052    0.049    0.041    0.037
 1.50         0.130    0.108    0.093    0.092    0.082    0.075    0.066    0.057    0.057    0.051    0.049    0.041    0.037

MOBILE PLANT - LOADING SHOVEL
              0.090    0.074    0.063    0.067    0.060    0.054    0.055    0.057    0.047    0.055    0.049    0.051    0.053

MOBILE PLANT - SLAVE VEHICLE
              0.000    0.000    0.000    0.000    0.000    0.000    0.000    0.000    0.016    0.014    0.012    0.021    0.018
```

```
SENSITIVITY RANGES CONSIDERED
  X OR / 2.00 : SITE RENT, PULVERISER AND BUILDING MAINTENANCE SLAVE VEHICLES AND VEHICLE FUEL
   X OR / 1.50 : MANUAL AND SUPERVISORY LABOUR, SITE RATES, SERVICES, DEPT. ADMIN., CAPITAL CHARGES,
VEHICLE MAINTENANCE
   X OR / 1.25: MATERIALS, PULVERISER ELECTRICITY, AND VEHICLE SPARES, TYRES & LICENCES

                                         RS VALUES
SEE COMMENT IN CAPITAL COST SECTION


T/D            25.     50.     75.     100.    125.    150.    200.    250.    300.    350.    400.    500.    600.
*******************************************************************************************************************

PULV.MT
 1.10         0,060   0.078   0.094   0.093   0.102   0.100   0.108   0.108   0.105   0.106   0.109   0.110   0.109
 1.50         0.058   0.075   0.090   0.090   0.098   0.096   0.104   0.104   0.101   0.102   0.104   0.105   0.105
 2.00         0.057   0.073   0.086   0.086   0.093   0.092   0.099   0.099   0.096   0.097   0.099   0.100   0.099

ELECTRIC      0.079   0.077   0.083   0.078   0.083   0.080   0.085   0.085   0.083   0.084   0.087   0.090   0.091

VEH.FUEL      0.010   0.009   0.009   0.009   0.009   0.008   0.009   0.009   0.010   0.010   0.010   0.010   0.011

V.MT.LAB      0.016   0.015   0.015   0.013   0.014   0.013   0.013   0.013   0.016   0.015   0.015   0.015   0.017

V.SPARES      0.004   0.005   0.005   0.005   0.005   0.005   0.006   0.006   0.007   0.007   0.007   0.007   0.007

V.TYRES       0.011   0.010   0.010   0.008   0.009   0.008   0.008   0.008   0.010   0.009   0.009   0.009   0.010

VEH.LIC       0.001   0.001   0.001   0.001   0.001   0.001   0.000   0.000   0.001   0.001   0.001   0.000   0.001

SLAVE VEHICLE (COMBINED OPERATING COST)
              0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.007   0.006   0.005   0.009   0.008

LABOUR        0.124   0.184   0.161   0.190   0.173   0.221   0.191   0.212   0.179   0.186   0.172   0.166   0.160

SUPER.LAB     0.081   0.061   0.053   0.042   0.039   0.033   0.028   0.024   0.040   0.035   0.033   0.028   0.035

MATERIALS     0.001   0.002   0.002   0.002   0.003   0.003   0.003   0.003   0.003   0.003   0.004   0.004   0.004

SERVICES      0.004   0.004   0.004   0.004   0.004   0.004   0.004   0.004   0.004   0.004   0.004   0.005   0.005

BUILD.MT      0.004   0.003   0.002   0.002   0.003   0.003   0.002   0.003   0.002   0.003   0.002   0.002   0.002

ADMIN
 1.10         0,044   0.050   0.056   0.053   0.055   0.053   0.054   0.052   0.049   0.047   0.048   0.046   0.044
 1.25         0.044   0.050   0.056   0.052   0.055   0.052   0.053   0.051   0.048   0.047   0.047   0.046   0.044
 1.50         0.043   0.049   0.055   0.052   0.054   0.051   0.053   0.051   0.048   0.046   0.047   0.045   0.043
```

```
RENT
 1.10     0.029   0.029   0.030   0.026   0.026   0.024   0.023   0.021   0.019   0.018   0.018   0.017   0.015
 1.50     0.028   0.028   0.029   0.026   0.026   0.024   0.023   0.021   0.019   0.018   0.018   0.017   0.015
 2.00     0.028   0.028   0.029   0.026   0.026   0.024   0.023   0.021   0.019   0.018   0.018   0.016   0.015

RATES
 1.10     0.019   0.019   0.019   0.017   0.017   0.016   0.015   0.014   0.013   0.012   0.012   0.011   0.010
 1.25     0.019   0.019   0.019   0.017   0.017   0.016   0.015   0.014   0.013   0.012   0.012   0.011   0.010
 1.50     0.019   0.019   0.019   0.017   0.017   0.016   0.015   0.014   0.013   0.012   0.012   0.011   0.010

CP.CHARGE 0.484   0.430   0.431   0.431   0.433   0.405   0.425   0.413   0.428   0.428   0.439   0.445   0.445
```

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RELATIVE SENSITIVITIES (RS) - CAPITAL COSTS
**********************************************

SENSITIVITY RANGES CONSIDERED
  X OR / 2.00 : SURVEY
  X OR / 1.50  : BUILDINGS, PULVERISER AND ANCILLARY EQUIPMENT, SITE PREPARATIONS
  X OR / 1.25  : LOADING SHOVEL AND SLAVE VEHICLES

                                    RS VALUES
LINEAR FUNCTIONS PRODUCE A CONSTANT RS VALUE FOR THE ENTIRE SENSITIVITY RANGE
CURVILINEAR FUNCTIONS DO NOT, INSTEAD SELECTED RS VALUES ARE GIVEN


T/D              25.     50.     75.    100.    125.    150.    200.    250.    300.    350.    400.    500.    600.

RATED CAP         5.     10.     10.     15.     15.     20.     20.     30.     30.     35.     35.     35.     40.
**************************************************************************************************************
SURVEY          0.066   0.065   0.065   0.064   0.064   0.064   0.064   0.063   0.064   0.063   0.064   0.064   0.064

BUILDINGS       0.301   0.353   0.397   0.419   0.446   0.459   0.490   0.501   0.517   0.525   0.538   0.554   0.563

PREPARE
  1.10          0.009   0.008   0.007   0.006   0.006   0.005   0.005   0.004   0.004   0.003   0.003   0.003   0.002
  1.25          0.009   0.008   0.007   0.006   0.006   0.005   0.005   0.004   0.004   0.003   0.003   0.003   0.002
  1.50          0.009   0.008   0.007   0.006   0.006   0.005   0.005   0.004   0.004   0.003   0.003   0.003   0.002

PULVERISER
                0.484   0.427   0.397   0.364   0.348   0.330   0.310   0.288   0.277   0.266   0.261   0.251   0.243

ANCILLARY       0.070   0.086   0.074   0.085   0.076   0.085   0.071   0.084   0.074   0.074   0.068   0.057   0.055

MOBILE PLANT - LOADING SHOVEL
                0.036   0.029   0.025   0.028   0.025   0.022   0.024   0.024   0.021   0.024   0.022   0.023   0.024

MOBILE PLANT - SLAVE VEHICLE
                0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.007   0.006   0.006   0.009   0.008
```

```
SENSITIVITY RANGES CONSIDERED
  X OR / 2.00 : SITE RENT, PULVERISER AND BUILDING MAINTENANCE, SLAVE VEHICLES AND VEHICLE FUEL
   X OR / 1.50 : MANUAL AND SUPERVISORY LABOUR, SITE RATES, SERVICES, DEPT. ADMIN., CAPITAL CHARGES,
VEHICLE MAINTENANCE
   X OR / 1.25 : MATERIALS, PULVERISER ELECTRICITY, AND VEHICLE SPARES, TYRES & LICENCES

                                                  RS VALUES
SEE COMMENT IN CAPITAL COST SECTION

T/D              25.      50.      75.     100.     125.     150.     200.     250.     300.     350.     400.     500.     600.
**********************************************************************************************************************************

PULV.MT         0.008    0.020    0.028    0.034    0.038    0.040    0.046    0.049    0.051    0.053    0.055    0.057    0.060

ELECTRIC        0.032    0.026    0.022    0.019    0.017    0.015    0.027    0.022    0.020    0.025    0.023    0.025    0.021

VEH.FUEL        0.006    0.006    0.006    0.006    0.006    0.006    0.006    0.006    0.007    0.007    0.007    0.006    0.007

V.MT.LAB        0.010    0.009    0.009    0.009    0.009    0.009    0.009    0.009    0.011    0.010    0.010    0.010    0.011

V.SPARES        0.003    0.003    0.003    0.003    0.004    0.004    0.004    0.004    0.004    0.004    0.004    0.004    0.005

V.TYRES         0.006    0.006    0.006    0.006    0.006    0.005    0.005    0.005    0.007    0.006    0.006    0.006    0.007

VEH.LIC         0.001    0.001    0.001    0.000    0.000    0.000    0.000    0.000    0.000    0.000    0.000    0.000    0.000

SLAVE VEHICLE (COMBINED OPERATING COST)
                0.000    0.000    0.000    0.000    0.000    0.000    0.000    0.000    0.005    0.004    0.004    0.006    0.005

LABOUR          0.073    0.060    0.077    0.066    0.078    0.084    0.083    0.082    0.082    0.073    0.082    0.081    0.070

SUPER.LAB       0.048    0.039    0.034    0.029    0.026    0.044    0.037    0.031    0.027    0.024    0.022    0.027    0.023

MATERIALS
 1.10           0.003    0.007    0.011    0.014    0.017    0.020    0.025    0.030    0.034    0.037    0.041    0.047    0.054
 1.15           0.003    0.007    0.011    0.014    0.017    0.020    0.025    0.029    0.034    0.037    0.041    0.047    0.053
 1.25           0.003    0.007    0.011    0.014    0.017    0.020    0.025    0.029    0.033    0.037    0.041    0.047    0.053

SERVICES        0.002    0.002    0.003    0.003    0.003    0.003    0.003    0.003    0.003    0.003    0.003    0.003    0.003

BUILD.MT        0.002    0.003    0.004    0.005    0.006    0.006    0.006    0.007    0.007    0.007    0.008    0.008    0.008

ADMIN           0.021    0.023    0.025    0.026    0.027    0.026    0.027    0.028    0.028    0.029    0.029    0.029    0.030

RENT
 1.10           0.017    0.019    0.019    0.018    0.018    0.016    0.015    0.014    0.013    0.012    0.012    0.011    0.010
 1.50           0.017    0.018    0.018    0.018    0.017    0.016    0.015    0.014    0.013    0.012    0.012    0.011    0.010
 2.00           0.017    0.018    0.018    0.018    0.017    0.016    0.015    0.014    0.013    0.012    0.012    0.011    0.010

RATES
 1.10           0.011    0.012    0.012    0.012    0.011    0.011    0.010    0.009    0.009    0.008    0.008    0.007    0.006
 1.25           0.011    0.012    0.012    0.012    0.011    0.011    0.010    0.009    0.009    0.008    0.008    0.007    0.006
 1.50           0.011    0.012    0.012    0.012    0.011    0.011    0.010    0.009    0.009    0.008    0.008    0.007    0.006

CP.CHARGE       0.704    0.707    0.689    0.696    0.683    0.662    0.651    0.654    0.647    0.649    0.642    0.630    0.635
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RELATIVF SFNSITIVITTES (RS) - CAPITAL COSTS
*********************************************

SENSITIVITY RANGES CONSIDERED
  X OR / 2.00 : SURVEY
  X OR / 1.50  : BUILDINGS, RALER AND ANCILLARY EQUIPMENT, SITFPREPARATIONS
  X OR / 1.25  : LOADING SHOVEL AND SLAVE VEHICLFS

                                        RS VALUES
LINEAR FUNCTIONS PRODUCE A CONSTANT RS VALUE FOR THE ENTIRF SENSITIVTTY RANGE
CURVILINFAR FUNCTIONS DO NOT, INSTEAD SELECTED RS VALUFS ARE GIVEN

T/D              50.       60.       75.       80.      100.      125.      150.      175.      200.      225.      250.      300.      320.

RATED CAP        15.       15.       23.       23.       23.       23.       30.       30.       30.       45.       45.       70.       70.
*******************************************************************************************************************************************
SURVEY          0.035     0.034     0.081     0.073     0.055     0.042     0.052     0.044     0.038     0.057     0.051     0.068     0.064

BUILDINGS       0.494     0.469     0.393     0.414     0.491     0.546     0.552     0.575     0.595     0.571     0.584     0.559     0.565

PREPARE
 1.10           0.023     0.023     0.018     0.016     0.012     0.010     0.008     0.007     0.006     0.005     0.004     0.004     0.003
 1.25           0.023     0.023     0.018     0.016     0.012     0.010     0.008     0.007     0.006     0.005     0.004     0.004     0.003
 1.50           0.023     0.022     0.017     0.016     0.012     0.010     0.008     0.007     0.006     0.005     0.004     0.004     0.003

BALER           0.270     0.256     0.282     0.255     0.194     0.149     0.146     0.123     0.107     0.129     0.116     0.136     0.128

ANCILLARY       0.057     0.105     0.137     0.141     0.159     0.172     0.171     0.176     0.181     0.173     0.176     0.168     0.169

MOBILE PLANT - LOADING SHOVEL
                0.086     0.081     0.062     0.074     0.056     0.043     0.033     0.035     0.030     0.025     0.027     0.021     0.026

MOBILE PLANT - SLAVE VEHICLE
                0.000     0.000     0.000     0.000     0.000     0.000     0.000     0.000     0.000     0.000     0.000     0.007     0.006
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SENSITIVITY RANGES CONSIDERED
   X OR / 2.00 : SITE RENT, BALER AND BUILDING MAINTENANCE BALING WIRE, SLAVE VEHICLES AND VEHICLE FUEL
    X OR / 1.50 : MANUAL AND SUPERVISORY LABOUR, SITE RATES, SERVICES, DEPT. ADMIN., CAPITAL CHARGES,
VEHICLE MAINTENANCE
    X OR / 1.25 : MATERIALS, BALER ELECTRICITY, AND VEHICLE SPARES, TYRES AND LICENCES

                                                            RS VALUES
 SEE COMMENT IN CAPITAL COST SECTION


T/D              50.       60.       75.       80.      100.      125.      150.      175.      200.      225.      250.      300.      320.
**********************************************************************************************************************************************

BALER MT       0.083     0.081     0.073     0.069     0.060     0.052     0.046     0.041     0.038     0.034     0.032     0.028     0.026

ELECTRIC       0.030     0.034     0.037     0.037     0.039     0.040     0.040     0.040     0.041     0.039     0.039     0.038     0.037

VEH.FUEL       0.010     0.010     0.009     0.009     0.008     0.008     0.007     0.007     0.007     0.006     0.007     0.007     0.006

V.MT.LAB       0.016     0.016     0.015     0.014     0.013     0.012     0.011     0.010     0.010     0.009     0.012     0.010     0.010

V.SPARES       0.005     0.005     0.005     0.005     0.005     0.005     0.005     0.004     0.004     0.004     0.005     0.004     0.004

V.TYRES        0.010     0.010     0.009     0.009     0.008     0.007     0.007     0.006     0.006     0.006     0.007     0.006     0.006

VEH.LIC        0.001     0.001     0.001     0.001     0.001     0.001     0.000     0.000     0.000     0.000     0.001     0.000     0.000

SLAVE VEHICLE (COMBINED OPERATING COST)
               0.000     0.000     0.000     0.000     0.000     0.000     0.000     0.000     0.000     0.000     0.000     0.004     0.004

LABOUR         0.195     0.185     0.160     0.149     0.124     0.102     0.085     0.091     0.081     0.081     0.073     0.078     0.090

SUPER.LAB      0.065     0.061     0.053     0.049     0.041     0.034     0.028     0.024     0.071     0.036     0.032     0.026     0.024

MATERIALS      0.006     0.006     0.006     0.008     0.015     0.022     0.025     0.028     0.030     0.030     0.032     0.032     0.032

BALE WIRE      0.049     0.054     0.057     0.056     0.057     0.058     0.057     0.056     0.056     0.053     0.053     0.051     0.050

SERVICES       0.000     0.001     0.002     0.002     0.003     0.003     0.003     0.004     0.004     0.004     0.004     0.004     0.004

BUILD.MT       0.003     0.003     0.002     0.002     0.002     0.003     0.002     0.002     0.002     0.002     0.002     0.001     0.002

ADMIN          0.043     0.045     0.045     0.044     0.043     0.042     0.040     0.039     0.039     0.036     0.036     0.034     0.033

RENT
 1.10          0.030     0.031     0.029     0.028     0.025     0.023     0.021     0.019     0.018     0.016     0.015     0.013     0.012
 1.50          0.030     0.031     0.029     0.028     0.025     0.023     0.020     0.019     0.017     0.015     0.015     0.013     0.012
 2.00          0.030     0.030     0.029     0.027     0.025     0.023     0.020     0.018     0.017     0.015     0.014     0.012     0.012

RATES
 1.10          0.020     0.020     0.019     0.018     0.017     0.015     0.013     0.012     0.011     0.010     0.010     0.008     0.008
 1.25          0.020     0.020     0.019     0.018     0.017     0.015     0.013     0.012     0.011     0.010     0.010     0.008     0.008
 1.50          0.020     0.020     0.019     0.018     0.016     0.015     0.013     0.012     0.011     0.010     0.009     0.008     0.008

CP.CHARGE      0.411     0.413     0.451     0.471     0.509     0.541     0.572     0.580     0.593     0.595     0.601     0.615     0.610
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APPENDICES ACCOMPANYING CHAPTER 9

APPENDIX 9A

Landfill:

Original Data

Disposal Capital Cost Data - Original Date (corrected to base date - March 1981)

t/d ① (t) / Cost(£)	20 (100000)	44 (110000)	60 (45000)	64 (80000)	90 (112500)	94 (117500)	150 (750000)	156 (195000)	160 (600000)	175 (218750)	176 (198000)	340 (765000)	354 (1062000)	385 (673750)	462 (1732500)	505 (1262500)
Site Acquisition	28000	Leased	N/A	Leased	N/A	N/A	N/A	60827	Leased	Leased	Leased	500	24000	Leased	45000	27000
Site Survey	0	N/A	N/A	0	648	N/A	N/A ⑦	0	0	N/A	0	1500?	3000?	3000?	3000?	3000?
Buildings and Civils	1500 ③	1000 ③	0	4447	N/A	N/A	30000	25208	2700 ③	3945?	17000	10000	56000	37111	44728	42000
Access Road	4000	6780	0	0	N/A	N/A	370000	17868	0	702?	N/A	19040	29000	11172	32000	17000
Drainage/ Leachate	2500 ②	0	31509 ⑤	30000 ⑥	2540	1647	15000 ⑤	7364	24780 ⑤	1698	17580	0	6400 ⑫	5548	18000	205000
Gas Collection/ Alleviation	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Mobile Plant	18500	N/A	35000 ④	23356	N/A	N/A	96000 ⑧	N/A ⑩	N/A	N/A ⑩	57000 ⑪	90000	N/A	N/A	N/A	N/A
Other Prep.	2000	0	21760	2692	N/A	N/A	14000 ⑨	18911	0	N/A	1218	0	32500	38624	10880	18000

① Total estimated capacity of each site

② Clay lining

③ Portable type of building

④ For two site vehicles

⑤ Peripheral run-off ditch and site grading

⑥ Culverting stream

⑦ It is known that independent consultants were commissioned at the feasibility and design stages

⑧ 2 tracked site vehicles + 1 dumper truck

⑨ Principally fencing

⑩ Steelwheel compactor

⑪ 1 steel-wheel compactor + 1 tracked vehicle

⑫ Excludes £1335500 for river diversion scheme

? Value uncertain

N/A Not available

Disposal Operating Cost Data - Original Data (Corrected to base date - March 1981)

t/d Cost (£)	10	16	17	20	41	44	60	60	62	64	68	70	88	90	94	96	142	149	156	160	175	175	176	180	200	308	340	354	370	385	462	484	525
Cover	333	0	3474	6000	0	2590	1221	0	2000	3330	0	1325	1000	1544	2403	1086	8895	13324	12030	0	1764	3546	0	1000	2100!	7500	0	36000	30186	40000	25000	8625	4700
Fuel	373	987	643	12033	11780	2078	1171	2000	1986	1271	1334	1409	23180	1864	1633	1834	3027	1787	1739	4830	2616	4079	5040	3280	3008	3703	4500	32000	18830	3200	3700	7321	37000
Vehicle Maintenance	1000	1471	12665			8851	1744	7000	4376	1894	1989	10947		9882	9002	10965	11562	10237	8347	9127	10757	24498	18027	4096	4000	12894	4000					[illegible]	
Spares		501				5462	594			650	612													1045	1500		3000						
Tyres		2367					2452	50		2662	2793									2871				4276	5150		5200						
Manual Labour	576	6915	6913	10500	5095	7590	6314	14986	4376	7410	6155	11918	10190	11918	11918	11900	11900	17013	17287	27540	11918	17287	14125	11491	13100	17237	27000	58000	46508	47000	47000	24474	77000
Supervisory Labour	0	0	0	0	0		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1044	0	0	0	N/A	14000	7042	14000	14000	0	14000
Materials	11	97?	200	0	17860	134	108?	280	265	108!	25!	1107	1580	300	119	291	10065	1990	1700	12500	1383	776	250	180?	250!	302	0	5200	7021	2003	8000	9579	1500
Services	0	120?	17	0	0	0	120?	④ 1430	0	288?	25?	65	300	216	37	153	77	68	12	④ 1839	21	103	210	120!	200!	58	470	800	419	700	1200	157	N/A
Buildings & Other Maint.	493?	109?	126	0	100	177	109!	4100	2566!	382?	25?	1034	0	241	7	28	133	56	0	③ 3675	55	232	650	0	400?	22	0	1600	1108	1000	765	169	850
Dept. Admin	736	N/A	N/A	0	25	929	N/A	4378	446?	N/A	N/A	N/A	40	N/A	N/A	N/A	N/A	N/A	N/A	9257	N/A	N/A	149	N/A	N/A	N/A	1000	N/A	2831	N/A	N/A	N/A	N/A
Site Rates	N/A	396	60	700	715	0	5480	9250	②	646	380	86	1000	35	355	60	0	200	600	250	20	1200	1700	8400	5159	3964	200	700	N/A	224	2300	1700	485
Site Rents	400	1100	1000	2262	2910	0			0			0	145	850	50	500	6000	6400	16600	1500	3300	530	2100			8050	0	0	0	550	0	13500	0
Vehicle Depot	714	N/A	①	4500	①	58.7	N/A	4227	2000	N/A	N/A	①	325	①	①	①	①	①	①	10343	①	①	12281	N/A	N/A	①	21530	①	①	①	①	①	①
Vehicle Licence & Insurance	116?	192	①	①	①	428	228	1380	200!	247	254	①	①	①	①	①	①	①	①	278	①	①	N/A	201	420	①	⑤	①	①	①	①	①	①

? Estimated values

N/A Not available

① Included in vehicle maintenance, tyres and spares cost above

② Included in Building Maintenance

③ Includes an element for minor construction work

④ Unusually large values for "services". No reason has been ascertained for this

⑤ Included in Vehicle Capital Charges

APPENDIX 9B

Landfill:

Descriptive Derivation of each First and Second Reduction Component Cost

9B.1 LANDFILL CAPITAL COSTS

Eight capital costs are identified, three of which, site acquisition, drainage and gas measures are assumed as zero in the base case. In order to accurately identify any trends between different sizes of landfill each capital cost has been appraised for three ranges of daily tonneage (10-200, 200-500 and 10-500) and three ranges of total capacity ($\leqslant$500000t, $\geqslant$500000t, all capacities). A "satisfactory" relationship has been taken as $R^2 \geqslant 0.70$ and where two or more variables were studied (eg. daily tonneage and total capacity) that producing the highest R^2 was used in subsequent analysis.

9B.1.1 BUILDINGS AND CIVILS

Observations and discussions with local authorities indicated that a wide range of standards exist for staff amenities. A number of landfills were seen that did not even offer the basic amenities that a workman could reasonably expect, and it is suspected that some sites may actually contravene one or more of the various Acts of Parliament regarding working conditions.

The design, material of construction and permanency of the buildings reflect the life of the site. Buildings on long-term sites are usually brick whereas those on short-term ones are of a more portable nature. In this study all sites are considered to have at least a 20 year lifetime.

The basic amenities considered acceptable and used in this work are: a messroom with lockers, drying and cooking facilities, toilet and washing facilities, tool room or store, fuel store. Amenities become larger in size and more extensive as throughput increases and more men are required. Additionally, larger sites should have a garage or enclosed compound for site vehicles, a small maintenance bay when steel-wheeled compactors are used, showers and a site office which may also include a weighbridge. The original data was supplemented where necessary to take account of these facilities and regression analysis subsequently found buildings costs are linearly related to daily tonneage.

9B.1.2 ACCESS ROADS

None of the sites observed had access roads longer than 0.75km in length and frequently they were much shorter.

Sites handling small daily tonneages only require single track roads with passing places, while larger sites need double track roads (≃6.5m wide) with a hard surface to handle the greater number of loads. At very busy sites roads of similar width are built though of a more substantial construction.

Access road costs produced a curvilinear relationship with daily tonneage.

9B.1.3 MOBILE PLANT

The capital cost of mobile plant was determined empirically from manufacturers' prices. These are listed below. Sites with ≤ 125t/d can operate satisfactorily with one vehicle to emplace refuse win and spread cover. Above 125t/d, two vehicles are required.

As discussed in Chapter 3 the superior speed and versitility of rubber-tyred vehicles makes them favoured by disposal authorities over tracked vehicles.

At sites above 150t/d, the emplacement vehicle favoured is the steel-wheeled compactor. This vehicle is unable to win or carry cover and consequently always has a tracked or rubber-tyred machine in support.

<u>Mobile Plant Prices (1981 £)</u>

t/d	10-25	25-50	50-75	75-125	125-150	150-175	175-225	225-300	300-400	400-500
Price(£1000)	15	20	30	50	65	80	85	90	95	110
Vehicle Type [£1000]	R	R	R	R	R[50] R[15]	S[65] R[15]	S[65] R[20]	S[70] R[20]	S[75] R[20]	S[85] R[25]

R = Rubber-tyred vehicle
S = Steel-wheeled compactor

9B.1.4 OTHER PREPARATION COSTS

The "preparation" cost comprises of two major components; fencing and stores. The first reduction gave low R^2 values for both the linear and curvilinear regressions, consequently, preparation costs were empirically derived.

Fencing: The length of fencing required depends upon the perimeter of the landfill site. For any given capacity this length is related to the packing density and the site depth. All landfills, irrespective of their emplacement method, will eventually produce the same site density ($1t/m^3$). Additionally, unlike the US. there are few deep landfills in Britian in the order of 20m depth, most are generally shallower than 10m. Thus assuming site depth is reasonably constant, perimeter length will tend to increase in relation with the total site capacity providing the site's configuration is not markedly elongated. To determine an approximate perimeter length the landfill was considered as a circular body and from which the minimum perimeter for a given volume can be derived. This minimum perimeter was then multiplied by 50% to take into account square, moderatly rectangular and irregular shaped sites.

Furthermore, since the site is considered to have a 20 year life, a reasonably substantial fence is required, typically, 2.5m high, chain link security fence with 1 or 2 strands of barbed wire a d concrete posts, at 1981 prices ≏ £10/m.

A sample perimeter length calculation is given in Fig. 9B.1.

Stores: This includes minor purchases and ancillary equipment such as furniture, fixtures and fittings, heaters, litter screens, hand tools and materials.

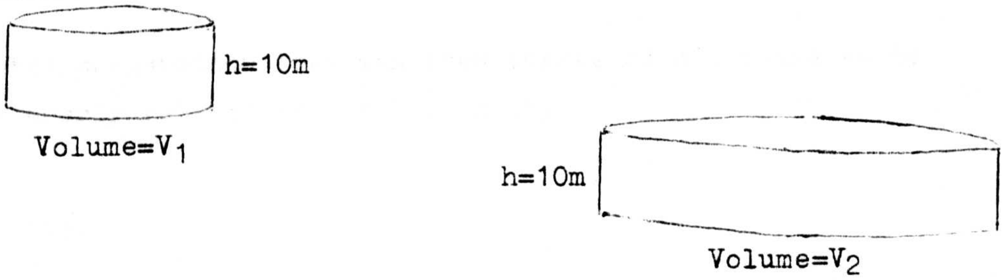
In the absence of any conflicting data a value of £1000 per site, irrespective of capacity, has been used.

A summary of preparation costs for selected site capacities is given below:

Fig 9B.1 Example perimeter calculations for circular landfills

Volume = $\pi r^2 h$ Circumference = $2\pi r$

Circular Body



Perimeter length for a 50,000t landfill

Using $V = \pi r^2 h$

$$50000 = 3{\cdot}142 \text{ x } r^2 \text{ x } 10$$

$$\frac{50000}{31{\cdot}42} = r^2$$

$$39{\cdot}89 = r$$

Using $C = 2\pi r$

$$C = 2 \text{ x } 3{\cdot}142 \text{ x } 39{\cdot}89$$

$$C = 250\text{m}$$

Perimeter length = 250m

Site Capacity (t)	50K	150K	250K	350K	500K	650K	750K	850K	950K
Circular Perimeter(m)	250	434	560	663	793	904	971	1033	1093
+ 50% (m)	125	217	280	332	396	452	486	517	546
Total Perimeter (m)	375	651	840	995	1189	1356	1457	1550	1639
@ £10/m fencing cost (£)	3750	6510	8400	9950	11890	13560	14570	15500	16390
Stores cost (£)	1000	1000	1000	1000	1000	1000	1000	1000	1000
Total Other Prep. cost (£)	4750	7510	9400	10950	12890	14560	15570	16500	17390

The total preparation cost was then regressed and found to be curvilinearly related to total capacity.

9B.1.5 SITE SURVEY

Site survey cost has been taken as 10% of the total capital cost of plant. This is based on the argument previously discussed in Appendix 8B.

9B.2 DISPOSAL OPERATING COSTS

Fourteen individual costs were identified which together comprise the total operating cost (excluding capital changes). One of these, cover purchase, was considered zero in the base case. The costs were only regressed against daily tonneage since operating costs annually recur and hence influenced by the daily (and subsequently annual) quantities handled rather than a site's total capacity.

9B.2.1 FUEL AND LUBRICANTS

It was apparent from the original data that many disposal authorities do not keep separate accounts for individual components of their mobile plant running costs such as, fuel and lubricants, maintenance labour, spares, tyres.

Therefore, it was necessary before analysis could be made to separate out where possible this aggregated data into estimated values for each component. These were calculated from those authorities which supplied non-aggregated data. The percentage of each component to the total running cost was derived and subsequently used to treat the aggregated cost figures supplied by other authorities.

Ratios with respect to fuel were derived from the percentage values of the other vehicle running costs and this gives an indication of the relative magnitude of the individual costs. Details of these calculations are in Table 9B.1. In this table the mean cost for fuel is higher for the 200-500t/d range than in the lower range, but the relative differences between fuel and the other running costs (except spares) are markedly lower. This suggests that fuel, maintenance, labour and tyres , costs on a large site will each tend towards a similar cost. A useful observation which will enable simplified estimation of vehicle running costs on sites over 500t/d.

The first reduction gave a cuvilinear relationship for fuel cost over the entire range of sites studied.

9B.2.2 MAINTENANCE LABOUR

Local authority officials have suggested that the fuel consumption of a vehicle depends upon its degree of utilisation. Furthermore, apart from routine attention, maintenance labour is also considered to be related to utilisation. It is therefore suggested that fuel consumption (and hence cost) is a good indicator of vehicle utilisation and that maintenance labour, spares and tyres will broadly follow similar relationships to fuel cost.

With this argument any one of the running costs which gave poor first reduction regression, in this instance maintenance labour, can be approximated to the fuel cost function. Accordingly, the second reduction maintenance costs were calculated from the ratios described in Table 9B.1.

TABLE 9B.1: Percentage and Relative Difference Between Site Vehicle Running Costs

Criteria	Non-aggregated values from Raw Data	Mean Annual Cost(£)	%	Non-aggregated values from Raw Data	Mean Annual Cost(£)	%
Fuel & Lubricants	987 1171 1271 1334 3280	1609	21.8	3508 3703 4500	3904	25.4
Maint. Labour	1471 1744 1894 1989 4096	2239	30.3	4000 4000	4000	26.0
Spares	501 594 650 672 1045	692	9.4	1500 3000	2250	14.6
Tyres	2067 2452 2662 2793 4276	2850	38.5	5250 5200	5225	34.0
		7390			15379	

Criteria	10-200	201-500
	Relative Difference with respect to fuel	
Fuel and Lubricants	1.0	1.0
Maint. Labour	1.39	1.02
Spares	0.43	0.57
Tyres	1.77	1.34

9B.2.3 SPARES AND TYRES COSTS

Both of these costs exhibited linear relationships with the first reduction regressions, both also gave their best fits to the available data over the entire range of daily tonneages.

9B.2.4 MANUAL AND SUPERVISORY LABOUR

Manual Labour: Labour costs were calculated from nationally-agreed payscales which lay down a basic wage, and to this an additional 70% was added to cover on-costs. This 70% value was the mode of actual percentages obtained from several authorities, consequently manual labour cost was evaluated as £3.30 per manhour.

The number of men on site was determined from the sites visited and the manning levels used in the base case for each size of site are listed in Table 9B.2. The number of men required on a landfill rises as the daily tonneage received increases, however, the time taken to handle each tonne of refuse drops markedly with increased arisings (Table 9B.3). This analysis suggests that labour is used more efficiently in larger operations than in smaller ones and continues to do so even if the former employ two men above the base case manning levels.

The manual labour costs have consequently been empirically derived from the base case manning levels and the fixed rate per manhour.

Supervisory Labour: Local authorities often do not consider a supervisory labour cost or account for it under another item of expenditure. Therefore data from those authorities which do evaluate this cost and

TABLE 9B.2: Base Case Manning Levels and Annual Manual Labour Costs for Different Sizes of Landfill Operations

Daily Tonneage	10-20	21-120	121-300	301-500	> 500
No. of Manual Staff	1	2	3	4	5
No. of Manhours per Year	2080	4160	6240	8320	10400
Annual Manual Labour Cost (£)	6900	13800	20700	26500	34500

Based on £3.30/manhour and rounded to nearest £100

TABLE 9B.3: Manual Labour Utilisation in Manhours per Tonne

Daily Tonnage	10	16	17	20	41	44	60	60	62	64	68	70	88	90	94	96	142	149	156	160	175	175	176	180	260	308	340	354	370	385	462	484	505
Manning Levels/Manhours Per Tonne																	1 0.059	1 0.056															
					1 0.203	1 0.189	1 0.139	1 0.139	1 0.134	1 0.130	1 0.123	1 0.119	1 0.095	1 0.093	1 0.089	1 0.087	2 0.117	2 0.112	2 0.107	2 0.104	2 0.095	2 0.095	2 0.095	2 0.093	2 0.064	3 0.081	3 0.074	3 0.071	3 0.068	3 0.065	3 0.054	3 0.052	4 0.066
BASE CASE	1 0.832	1 0.520	1 0.489	1 0.416	2 0.406	2 0.378	2 0.277	2 0.277	2 0.268	2 0.260	2 0.245	2 0.239	2 0.189	2 0.185	2 0.177	2 0.173	3 0.176	3 0.168	3 0.160	3 0.156	3 0.143	3 0.143	3 0.142	3 0.139	3 0.096	4 0.108	4 0.098	4 0.094	4 0.090	4 0.086	4 0.072	4 0.069	5 0.082
	2 1.664	2 1.040	2 0.978	2 0.832	3 0.609	3 0.567	3 0.416	3 0.416	3 0.402	3 0.390	3 0.368	3 0.357	3 0.284	3 0.278	3 0.266	3 0.260	4 0.235	4 0.224	4 0.213	4 0.208	4 0.191	4 0.191	4 0.189	4 0.185	4 0.128	5 0.135	5 0.123	5 0.118	5 0.113	5 0.108	5 0.090	5 0.086	6 0.098
					4 0.812	4 0.756	4 0.554	4 0.554	4 0.536	4 0.520	4 0.490	4 0.476	4 0.378	4 0.370	4 0.354	4 0.346	5 0.293	5 0.280	5 0.267	5 0.260	5 0.238	5 0.238	5 0.237	5 0.232	5 0.160	6 0.162	6 0.147	6 0.141	6 0.135	6 0.129	6 0.108	6 0.104	7 0.115
																										7 0.189	7 0.172	7 0.165	7 0.158	7 0.151	7 0.126	7 0.121	8 0.131

published literature was used to estimate supervisory manhours as 10% of manual labour manhours on smaller sites (<300t/d) and 15% on larger landfills. Supervisory labour cost was approximated as £4.30 per manhour.

9B.2.5 MATERIALS

The very large materials costs is the original data for some sites included cover purchase. These values were reduced where possible to exclude cover. A plot of the materials costs for each site produced no clear trend, but a frequency distribution of the unit costs (per tonne) was highly skewed about 0.020£/t. In the absence of additional information this unit cost was used over the range 10-500t/d. The corresponding linear annual cost was used for the second reduction figures.

9B.2.6 SERVICES

The type of services on a landfill site vary widely. At the very least one should reasonably expect a telephone, electricity for lighting and hot water, plumbed fresh and foul water systems, bottled gas for cooking, emergency lighting and heating. The operating costs associated with those services would be telephone and electricity charges, water rates and gas purchase. Where no data was available in the first reduction or suspected of being an underestimate, the costs for particular sites were based on those of similar sized operations. The following scale was used:

10-100t/d	£100
101-200t/d	£150
201-500t/d	£200

The first reduction gave low R^2 values. Unlike the "materials" cost no single unit cost was apparent for the entire range of sites. Instead, the distribution of values collected from local authorities was found to be bimodal.

Sites between 10-100t/d gave a unit cost of 0.014£/t and between 101-500t/d, 0.005£/t. This change at approximagely 100t/d is not fully understood but may represent an economy of scale whereby 3, 4 and 5 men can almost "live" as cheaply as 1 or 2. The corresponding annual costs wereused to calculate the second reduction figures.

9B.2.7 BUILDINGS AND OTHER MAINTENANCE

All site buildings, roads and fences require maintenance. Where no data was available or quoted values were suspected as being underestimated (eg. £0p.a.) the first reduction costs at particular sites were changed to those of similar sized operations. The following scale was used:

10-100t/d	£200
101-200t/d	£500
201-300t/d	£800
301-400t/d	£1100
401-500t/d	£1400
501-600t/d	£1700

9B.2.8 SITE RENT

Site rents reflect the land values prevailing in each disposal district or part thereof. Often rents are set at the level the market will bear. The first reduction regressions gave low R^2 values and this was expected since these costs encompass historic leasing agreements and the rents paid are artificially lower in some cases than would be expected in 1981. Leasing agreements can be based on pence per m^3 of airspace or on a single annual payment irrespective of the airspace filled. However, the former method is the most commonly used for landfill operations. The unit cost of airspace was found to range from 6p to 35p per m^3 and a compromise value of 10p per m^3 was used in subsequent calculations.

The quantity of airspace required is dependant upon the density of the refuse, those typically achieved are:

$0.65t/m^3$ for rubber-tyred loaders (ie. $0.46t/m^3$ on emplacement, with increasing density from maturing refuse emplaced earlier in the year. Therefore an estimated density over one year's operation was taken as $0.65t/m^3$

$0.80t/m^3$ for steel-wheeled compactors (based on the same argument outlined above)

Thus, the volume required for 1 tonne of refuse is given by:

Rubber-tyred: $\frac{1}{0.65t/m^3} = 1.54m^3/t$ (10 to 150t/d)

Steel-wheel: $\frac{1}{0.80t/m^3} = 1.25m^3/t$ 151 to 500t/d)

The second reduction costs were subsequently calculated from:

Site Rent (ie. Total Airspace Cost) = Annual Tonneage x Volume/tonne x 0.010 £/m^3

9B.2.9 SITE RATES

The low R^2 values from the first reduction figures were unexpected since the "general rate" is calculated as a particular fraction in the pound and based on the rateable value of each property. The rateable value itself is related to the "annual value of the property" although the exact fraction (poundage) levied by each authority will vary. Consequently, the rent or lease payments for a site should be a reasonable, though not exact, measure of the "annual value" of the property. For public utilities the rateable value is usually based on the "net rent" paid (ie. market rent less a proportion for upkeep of the property by the tenant).

In the second reduction the site rates are considered to be related to site rent and both will increase as daily tonneage rises. The practice of some authorities to waiver rates on their own disposal sites has been ignored. The mean non-domestic rate poundage (excl. watercharges) for England, Scotland and Wales was calculated as 112p in the pound. Discussions with authorities suggest a wide range of reductions in gross rent to produce the net rent.

Net rents (ie. rate poundage) were taken as 15% of gross rent (mean of 12 sites). The second reduction site rates were calculated accordingly as 15% of site rents, multiplied by the rate poundage, ie.

Site Rates = Site Rent x 0.15 x £1.12
(ie. Gross Rent)

By definition the base case site rates will follow a similar mathematical function to site rents

9B.2.10 VEHICLE LICENCES AND INSURANCE

The licences costs were incomplete for a number of sites and where unavailable or in an aggregated form estimates were made based on the values for similar sized operations, ie.

10- 40t/d	£200
41-100t/d	£250
101-200t/d	£300
201-500t/d	£500

9B.2.11 DEPARTMENTAL ADMINISTRATION

Similar to the experience with supervisory labour costs, departmental administration is almost universally excluded from the operating costs of individual landfills. In the few cases where it is apportioned it is usually at the same percentage as the total disposal operating cost is to the total department budget for all services. Accordingly, the second reduction figures have been estimated as 10% of the landfill total operating cost excluding capital charges.

This cost will by definition follow a similar relationship to that of the total operating cost.

APPENDIX 9C

First Reduction Costs and Corresponding R^2 Values

First Reduction Regressions on Capital Costs - R^2 Values

Cost	Costs with Daily Tonneage						Costs with Total Site Capacity					
	10-200t/d		201-500t/d		10-500t/d		< 500000t/d		≥ 500000t/d		All capacities	
	XY	LogX LogY	XY	LogX LogY	XY	LogX LogY	XY	LogX LogY	XY	LogX LogY	XY	LogX LogY
Buildings & Civils	0.74*	0.40	0.12	0.23	0.52	0.10	0.47	0.62	0.26	0.24	0.53	0.47
Access Road	0.80	0.93*	0.04	0.03	0.34	0.10	0.85	0.82	0.29	0.32	0.52	0.62
Mobile Plant	0.95*	0.90	E		E		0.19	0.38	E		E	
Other Prep. Costs	0.24	0.18	0.66	0.60	0.30	0.06	0.26	0.34	0.01	0.23	0.08	0.00

Site Survey - insufficient values for regression analysis. Site acquisition, Gas Allevaition and Drainage Measures Costs - excluded from 1st reduction analyses

* ≥ 0.70 and relationship used in subsequent analyses

E Empirically derived

First Reduction Regressions on Operating Costs - R^2 Values

t/d	10-500		10-200		101-500		10-100		101-200		201-500	
Cost	XY	LogX LogY	XY	LogX LogY	XY	LogX LogY	XY	LogX LogY	XY	LogX LogY	XY	LogX LogY
Fuel	0.80	0.78	0.22	0.00	0.61	0.00	0.05	0.01	0.06	0.04	0.49	0.58
Maintenance Lab.	0.47	0.60	0.26	0.42	0.35	0.36	0.00	0.11	0.07	0.12	0.42	0.48
Spares	0.86	0.76	0.48	0.51	0.77	0.77	0.02	0.24	0.00	0.00	0.47	0.57
Tyres	0.79	0.72	0.57	0.51	0.60	0.58	0.02	0.23	0.02	0.01	0.42	0.48
Manual Labour	0.86	0.95	0.90	0.93	0.81	0.82	0.69	0.85	1.00	1.00	0.53	0.57
Supervisory Labour	0.94	0.93	0.90	0.93	0.86	0.88	0.69	0.85	1.00	1.00	0.53	0.55
Materials	0.60	0.28	0.22	0.50	0.60	0.04	0.21	0.45	0.66	0.57	0.80	0.34
Services	0.29	0.02	0.02	0.04	0.24	0.00	0.17	0.11	0.31	0.38	0.01	0.09
Building Maint.	0.09	0.00	0.01	0.00	0.24	0.03	0.00	0.00	0.17	0.22	0.03	0.09
Dept. Admin	0.86	0.87	0.78	0.78	0.77	0.71	0.63	0.81	0.51	0.51	0.75	0.75
Site Rates	0.21	0.04	0.02	0.51	0.22	0.00	0.00	0.00	0.51	0.51	0.16	0.03
Site Rent	0.03	0.13	0.19	0.05	0.03	0.41	0.04	0.08	0.32	0.27	0.30	0.01
Vehicle Licence & Insurance	0.48	0.56	0.03	0.26	0.79	0.80	0.04	0.27	0.15	0.15	0.31	0.31

DISPOSAL CAPITAL COST DATA

FIRST REDUCTION

t/d (t)(1) Cost	20 (100000)	44 (110000)	60 (45000)	64 (80000)	90 (112500)	94 (117500)	150 (750000)	156 (195000)	160 (600000)	175 (218750)	176 (198000)	340 (765000)	354 (106200)	385 (673750)	462 (1732500)	505 (1262500)
Site Acquisition	Assumed all sites leased															
Site Survey	0	0	0	0	648	0	0	0	0	0	0	1500	3000	3000	3000	3000
Buildings (2	15000	10000	(3)0	6421	(3)0	(3)0	30000	25208	(4) 2721	(4) 3945	27880	10000	56000	37111	44728	42000
Access Roads	4000	6780	(3)0	(3)0	(3)0	(3)0	(5) 30000	17868	(3)0	(4) 702	(3)0	19040	29000	11172	32000	17000
Drainage/ Leachate	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Gas Collection/ Alleviation	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Mobile Plant (6)	18500	20000	20000	30000	50000	50000	65000	65000	65000	80000	80000	95000	95000	95000	110000	110000
Other Prep.	2000	(3)0	21760	2692	(3)0	(3)0	14000	18911	(3)0	(3)0	1218	(3)0	32500	38624	10880	18000

① Total estimated capacity of each site

② All but the smallest site considered to have brick-built facilities

③ Zero values were not included in the regression analyses. N/A values in row data taken as zero in 1st Modification.

④ This outlying value was excluded from subsequent analysis

⑤ The large value of 370000 in the raw data for a $1\frac{1}{3}$ mile road. This has been reduced down to the base case length of 0.5-0.75Km

⑥ Cost of plant was laid down in the base case and is outlined under mobile plant debt (disposal operating costs).

Disposal Operating Cost Data - First Reduction (Annual Costs)

Cost (£) \ t/d	10	16	17	20	41	44	60	60	62	64	68	70	88	90	94	96	142	149	156	160	175	175	176	180	260	308	340	354	370	385	462	484	505
Cover	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Fuel	700	487	643	1245	2596	2078	1171	2200	2300	1271	1334	1409	1091	1864	1633	1834	2037	2037	1982	4830	3000	4079	4737	3280	3500	3703	4500	5334	6604	5334	5334	7321	5334
Vehicle Maintenance	333	1471	1467	1868	1948	8851	1744	1175	1459	1894	1989	1633	1636	1333	1328	1667	3600	3600	3024	6754	4000	4080	5600	4096	4000	4494	4000	5460	6760	5460	5460	8023	5460
Spares	148	501	651	830	866	1214	594	522	648	650	672	726	727	593	590	741	1200	1200	1008	2373	1200	1224	1680	1045	1500	1200	3000	3066	3796	3066	3066	4612	3066
Tyres	519	2067	2281	2906	3029	4248	2452	1818	2269	2662	2793	2541	2546	2074	2080	2593	5100	5100	4284	2871	4800	4896	6720	4276	5250	4800	5200	7140	8840	7140	7140	10739	7140
Manual Labour	6900	6900	6900	6900	13800	13800	13800	8800	13800	13800	13800	13800	13800	13800	13800	13800	20700	20700	20700	20700	20700	20700	20700	20700	20700	26500	26500	26500	26500	26500	26500	26500	34500
Supervisory Labour	890	590	890	890	1790	1790	1790	1790	1790	1790	1790	1790	1790	1790	1790	1790	2680	2680	2680	2680	2680	2680	2680	2680	2680	5300	5300	5300	5300	5300	5300	5300	6900
Materials	11	97	200	150	194	134	108	280	265	108	100	1100	3580	300	1119	291	2065	1990	1700	2500	1383	776	250	180	250	302	0	5000	7029	2000	8000	9579	13500
Services	100	120	100	100	100	100	120	100	100	288	100	65	300	216	100	153	77	68	150	150	150	103	210	120	200	200	470	800	419	700	1200	157	150
Buildings and Other Materials	493	109	126	100	100	177	109	200	2000	182	200	1034	100	241	100	100	103	100	200	150	100	202	650	200	400	200	200	1600	408	1000	765	169	850
Dept. Admin	1156	1611	1511	1968	2571	3675	2274	3360	2661	2670	2418	2602	2824	2426	2413	2474	4706	4719	4603	5039	4426	4308	5054	4823	7115	7768	4987	6140	6685	5777	6557	8810	8212
Site Rates	100	396	60	700	715	700 ①	2480 ①	1700 ①	100	100 ①	100 ②	100	1000	35	385	60	300	200	600	250	300	1000	1700	2000 ②	1160 ②	3864	200	700	0	224	2300	170	488
Site Rents	400	1100	1000	1200	2910	3000 ②	3000 ①	6550 ①	500	550 ①	300 ②	500	145	850	50	600	6000	6400	6600 ④	3500	3000	500	2100	6400 ②	4000 ②	8000	0 ⑤	0 ⑤	0 ⑤	550	0 ⑤	3500	0 ⑤
Vehicle Licence & Insurance	116	192	200	200	250	425	228	690 ③	280	247	254	250	250	250	250	250	300	300	300	278	300	300	300	250	420	300	500	500	500	500	500	500	500

① Deduced from 81/82 estimates for base year 1980/81

② Deduced from aggregated raw data using values similar to other sites with approx. same t/d

③ Value for one site vehicle

④ Reduced from 16600 due to inclusion of an element for land purchase

⑤ Omitted from 1st reduction regression analysis

APPENDIX 9D

Landfill:

Second Reduction Costs and Corresponding R^2 Values

Second Reduction Regressions on Capital Costs - R^2 Values

Cost	Costs with Daily Tonneage						Costs with Total Site Capacity					
	10-200t/d		201-500t/d		10-500t/d		< 500000t		≥ 500000t		All tonneages	
	XY	LogX LogY	XY	LogX LogY	XY	LogX LogY	XY	LogX LogY	XY	LogX LogY	XY	LogX LogY
Site Survey	E		E		E		E		E		E	
Buildings & Civils	0.74*	0.40	0.78*	0.74	0.78①	0.72	0.47	0.62	0.34	0.20	0.67	0.66
Access Road	0.80	0.93*	0.57	0.54	0.61	0.85*②	0.85	0.82	0.22	0.25	0.61	0.64
Mobile Plant	E		E		E		E		E		E	
Other Prep. Costs	E		E		E		E		E		E	
Total Capital Costs	0.95*	0.89	0.96	0.97	0.88	0.92	0.93	0.93	0.56	0.51	0.74	0.79

In base case Site Acquisition, Drainage and Gas Alleviation regarded as £0

* Largest R^2 value ≥ 0.70 and relationship used in subsequent analyses

① The equations for each range gave better estimates to the 1st reduction figures than the single overall equation

② This relationship was used to derive the access road costs over the range 201-500t/d in subsequent analyses

Second Reduction Regressions on Operating Costs - R^2 Values

t/d Cost	10-500		10-200		101-500		10-100		101-200		201-500	
	XY	LogX LogY	XY	LogX LogY	XY	LogX LogY	XY	LogX LogY	XY	LogX LogY	XY	LogX LogY
Fuel	*0.80	0.78	0.57	0.60	0.61	0.60	0.14	0.38	0.38	0.48	0.49	0.58
Maintenance Lab.	0.61^E	0.71^E	0.57^E	0.59^E	0.07^E	0.11^E	0.14^E	0.38^E	0.38^E	0.48^E	0.49^E	0.59^E
Spares	*0.86	0.76	0.48	0.51	0.76	0.77	0.02	0.24	0.00	0.00	0.47	0.57
Tyres	*0.79	0.72	0.57	0.51	0.60	0.58	0.02	0.23	0.02	0.01	0.42	0.48
Manual Labour	0.86^E	0.95^E	0.90^E	0.93^E	0.81^E	0.82^E	0.69^E	0.85^E	E	E	0.53^E	0.57^E
Supervisory Labour	0.94^E	0.93^E	0.90^E	0.93^E	0.86^E	0.88^E	0.69^E	0.85^E	E	E	0.53^E	0.55^E
Materials	E	E	E	E	E	E	E	E	E	E	E	E
Services	0.82^E	0.81^E	0.21^E	0.66^E	E	E	E	E	E	E	E	E
Building Maint.	E	E	E	E	E	E	E	E	E	E	E	E
Dept. Admin	0.95^E	0.96^E	0.92^E	0.93^E	0.95^E	0.93^E	0.68^E	0.87^E	0.32^E	0.34^E	0.88^E	0.90^E
Site Rates	0.99^E	0.99^E	0.96^E	0.99^E	0.99^E	0.77^E	E	E	0.10^E	0.08^E	E	E
Site Rent	0.99^E	0.99^E	0.96^E	0.99^E	0.99^E	0.97^E	E	E	0.10^E	0.08^E	E	E
Vehicle Licence & Insurance	*0.82	0.76	0.70	0.80	0.67	0.58	0.63	0.74	0.15	0.15	0.25	0.22
Total Operating Cost (Excluding Capital Charges)	0.95	*0.96	0.92	0.93	0.94	0.93	0.68	0.87	0.32	0.35	0.88	0.90

E Some or all 2nd reduction costs empircally derived. Where no R2 value given costs produced a perfect fit.

* For the non-empirical relationships the highest R^2 value above 0.70 has been used. Where both XY and Log X Log Y regressions gave the same R^2 - the former is used subsequently.

DISPOSAL CAPITAL COST DATA - 2ND REDUCTION

t/d (t)(1) Cost	20 (100000)	44 (110000)	60 (45000)	64 (80000)	90 (112500)	94 (117500)	150 (750000)	156 (195000)	160 (600000)	175 (218750)	176 (198000)	340 (765000)	354 (106200)	385 (673750)	462 (1732500)	505 (1262500)
Site Acquisition	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Site Survey	4032	4336	4796	5240	8801	8919	14057	11650	12844	14208	14125	16055	16633	18130	20986	21302
Buildings	15000	10000	(2) 13736	6421	(2) 17576	(2) 18088	30000	25208	(2) 26536	(2) 28456	27880	(2) 30749	(3) 24000	37111	44728	42000
Access Roads	4000	6780	(2) 9654	(2) 10219	(2) 13794	(2) 14332	30000	17868	(2) 22887	(2) 24764	(2) 24889	19040	29000	(2) 34384	32000	(2) 41126
Drainage/ Leachate	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Gas Collection/ Alleviation	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Mobile Plant	15000	20000	20000	30000	50000	50000	65000	65000	65000	80000	80000	95000	95000	95000	110000	110000
Other Prep.	6320	6580	4570	5760	6640	6760	15570	8420	14020	8860	8480	15707	18328	14802	23122	19893
TOTALS	44352	47696	52756	57640	96811	98098	154627	128146	141287	156288	155374	176601	182961	199427	230847	234321

(1) Total estimated capacity of each site

(2) Figure interpolated from 1st red. regression value and subsequently used in 2nd red.

(3) Reduced from 1st reduction value after obtaining further information.

Disposal Operating Costs - Second Reduction Annual Costs

t/d ①	10	16	17	20	41	44	60	60	62	64	68	70	88	90	94	96	142	149	156	160	175	175	176	180	260	308	340	354	370	385	462	484	505
Cost(£)	(2500)	(4000)	(4250)	(5000)	(10250)	(11000)	(15000)	(15000)	(15500)	(16000)	(17000)	(17500)	(22000)	(22500)	(23500)	(24000)	(35500)	(37250)	(39000)	(40000)	(43750)	(43750)	(44000)	(45000)	(65000)	(77000)	(85000)	(88500)	(92500)	(96250)	(115000)	(121000)	(12625)
Cover	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Fuel	700	987	643	1245	2596	2078	1171	2200	2300	1217	1334	1409	1091	1864	1633	1834	2037	2037	1982	4830	3000	4079	4737	3280	3508	3703	4500	5334	6604	5334	5334	7321	5334
Vehicle Maint.	973	1374	894	1731	3608	2888	1628	3058	3179	1692	1854	1959	1516	2591	2270	2549	2831	2831	2755	6714	4170	5670	6584	4559	3578	3779	4590	5441	6736	5441	5441	7467	5441
Spares	148	501	651	830	866	1214	594	522	648	650	672	726	727	593	590	741	1200	1200	1008	2373	1200	1224	1680	1045	1500	2523	3000	3066	3796	3066	3066	4612	3066
Tyres/Wheels	519	2067	2281	2906	3029	4248	2452	1828	2269	2662	2793	2541	2546	2074	2080	2593	5100	5100	4284	2871	4800	4896	6720	4276	5250	5877	5200	7140	8840	7140	7140	10739	7140
Manual Labour	6900	6900	6900	6900	13800	13800	13800	13802	13800	13800	13800	13800	13800	13800	13800	13800	20700	20700	20700	20700	20700	20700	20700	20700	20700	26500	26500	26500	26500	26500	26500	26500	34500
Supervisory Lab.	890	890	890	890	1790	1790	1790	1790	1790	1790	1790	1790	1790	1790	1790	1790	2680	2680	2680	2680	2680	2680	2680	2680	2680	5300	5300	5300	5300	5300	5300	5300	6900
Materials	50	80	85	100	205	220	300	300	310	320	340	350	440	450	470	480	710	745	780	800	875	875	880	900	1300	1540	1700	1770	1850	1925	2310	2420	2520
Services	35	56	60	70	144	154	210	210	217	224	238	245	308	315	329	336	178	186	195	200	219	219	220	225	325	385	425	443	463	481	578	605	631
Buildings & Other Maint.	200	200	200	200	200	200	200	200	200	200	200	200	200	200	200	200	500	500	500	500	500	500	500	500	800	1100	1100	1100	1100	1100	1400	1400	1700
Dept. Admin.	1107	1410	1365	1615	2870	2907	2520	2714	2809	2561	2649	2658	2674	2822	2784	2913	4256	4292	4213	4956	4494	4782	5233	4514	4957	6135	6433	6828	7430	6994	7323	8333	8467
Site Rates	65	104	110	129	265	285	388	388	401	414	440	452	569	582	608	621	918	964	1009	1035	919	919	924	945	1365	1617	1785	1859	1943	2021	2426	2541	2651
Site Rents	385	616	655	770	1580	1694	2310	2310	2387	2464	2618	2695	3388	3465	3619	3696	5467	5737	6006	6160	5469	5469	5500	5625	8125	9625	10625	11063	11563	12031	14438	15125	15781
Vehicle Lic. & Ins.	116	192	200	200	250	220②	228	230②	250	247	254	250	250	250	250	250	300	300	300	278	300	300	300	250	420	300	500	400	500	500	500	500	500
TOTALS	12088	15377	14934	17506	31203	31698	27591	29556	30560	28261	28982	29075	29299	30796	30423	31803	46877	47272	46412	54097	49326	52313	56658	49499	54408	68382	71658	76378	82625	77833	81756	92863	94636

1 Annual Tonneage

2 **Outlier:** Values interpolated from Second Reduction cost function

APPENDIX 9E

Modifications to Base Case Operating Costs to Account for Landfilling Baled, Wet and Dry Pulverised Wastes

Baled Refuse

Capital Costs

	Daily Tonneage	50	75	100	150	200	250	300	350	400	450	500
	Summated Base Case	55435	75838	105774	139811	178147	171315	181907	197094	206957	231550	240915
LESS	Difference between the emplacement vehicle costs and baled landfill equipment	0	(10000)	(20000)	(20000)	(45000)	(30000)	(30000)	(35000)	(35000)	(25000)	(25000)
		←	1 forklift			✗	2 forklifts				✗ 3 forklifts	
	Baled landfill Capital Cost	55435	65838	85774	119811	133147	141315	151907	162094	171957	206550	215915

For subsequent purpose the revised total operating costs are rounded off to the nearest £100

Amortisation

	Base Case	10395	14606	21660	28358	36408	36643	37975	40714	41957	47536	48718
LESS	Difference in mobile plant annual charges	0	(2913)	(8739)	(8739)	(13109)	(8739)	(8739)	(10196)	(10196)	(7283)	(7283)
	Baled landfill Capital Charges	10395	11693	12921	19619	23299	27904	29236	30518	31761	40253	41435

Baled Landfill

OPERATING COSTS

Baled refuse is assumed to have a similar effective density as untreated landfills using steel-wheeled compactors. Therefore, no saving in airspace or reduction in quantity of cover is considered for sites over 150t/d. Untreated sites ≤ 150t/d use approximately 25% more volume for a similar quantity of refuse. Baled refuse saves 25% of airspace cost at these sites.

Site vehicle running costs are said to be reduced space handling and travelling over a more stable material. While several authors claim a reduced operating cost (eg. Stone et al, 1977) this is a marked absence or reluctance to produce supporting evidence. It is interesting to note that manufacturers' literature barely touches upon this aspect and therefore a conservative estimate of a 10% reduction is used in this analysis. Savings are principally going to be in maintenance and tyre costs.

	Daily Tonneage	50	75	100	150	200	250	300	350	400	450	500
	Summated Base Case (untreated landfill)	27881	30972	34198	47231	51695	56527	69976	74630	79522	84066	88569
LESS	Airspace savings @ 25% of B.C.	(444)	(666)	(888)	(1331)	0	0	0	0	0	0	0
LESS	Site Vehicle Running Costs @ 10% of B.C.	(687)	(811)	(927)	(1148)	(1359)	(1564)	(1765)	(1962)	(2156)	(2348)	(2539)
	Baled landfill cost with on-site cover (excl. capital charges)	26750	29495	32383	44752	50336	54963	68211	72668	77366	81718	86030
	Capital Charges	10395	11693	12921	19619	23299	27904	29236	30518	31761	40253	41435
	Baled landfill cost with on-site cover (incl. capital charges)	37145	41188	45304	64371	73635	82867	97447	103186	109127	121971	127465
	Rounded off Total Baled landfill cost with on-site cover	37100	41200	45300	64400	73600	82900	97400	103200	109100	122000	127500
	Unit cost. Baled landfill cost with on-site cover	2.97	2.20	1.81	1.72	1.47	1.33	1.30	1.18	1.09	1.08	1.02

For sites using no cover, the capital cost of the support vehicle is excluded for sites > 125t/d. Appropriate changes to the capital charges are also made. This type of operation may be unsatisfactory on environmental grounds.

Unit cost. Baled landfill cost with no cover	2.97	2.20	1.81	1.48	1.27	1.14	1.13	1.05	0.97	0.95	0.90

Dry Pulverised Refuse

CAPITAL COSTS

No change in the base case capital costs are envisaged

OPERATING COSTS

Similar effective density is achieved to untreated refuse emplaced with a steel-wheeled compactor. No airspace savings for sites >150t/d. Sites <150t/d untreated refuse requires 18% more volume, therefore dry pulverised refuse saves approximately 18% of airspace cost at these sites.

Minor savings on vehicle running costs possibly with tyre repairs. No evidence found in the literature, therefore an arbitrary saving of 5% has been used in this study.

All other operating costs are considered unaffected.

	Daily Tonneage	25	50	75	100	150	200	250	300	350	400	450	500
	Summated Base Case (untreated landfill)	24485	27881	30972	34198	47231	51695	56527	69976	74630	79522	84066	88569
LESS	Airspace savings @ 18% of Base Case	(160)	(320)	(479)	(639)	(959)	0	0	0	0	0	0	0
LESS	Site Vehicle Running Costs @ 5% of Base Case	(274)	(344)	(406)	(464)	(574)	(680)	(782)	(883)	(981)	(1078)	(1174)	(1270)
	Dry Pulverised landfill with on-site cover (excl. capital charges)	24051	27217	30087	33095	45698	51015	55745	69093	73649	78444	82892	87299
	Capital Charges (from Base Case)	7508	10395	14606	21660	28358	36408	36643	37975	40714	41957	47536	48718
	Dry pulverised landfill with on-site cover (incl. capital charges)	31559	37612	44693	54755	74056	87423	92388	107068	114363	120401	130428	136017
	Rounded off Total Dry Pulverised landfill with on-site cover	31600	37600	44700	54800	74100	87400	92400	107100	114400	120400	130400	136000
	Unit cost. Dry Pulverised landfill with on-site cover	5.60	3.01	2.38	2.19	1.98	1.75	1.48	1.43	1.31	1.20	1.16	1.09

For sites using no cover the capital cost of the support vehicle is excluded for sites >125t/d. Appropriate changes to the capital charges are also made. This type of operation may be unsatisfactory on environmental grounds.

Unit cost. Dry Pulverised landfill with no cover	5.60	3.01	2.38	2.19	1.86	1.63	1.38	1.35	1.24	1.15	1.09	1.03

Wet Pulverised Refuse

CAPITAL COSTS

No change in the base case capital costs are envisaged.

OPERATING COSTS

Evidence from the literature (Campbell and Parker, 1980) suggests the following improvements in effective density over untreated refuse: Sites ≤ 150t/d 40% saving in airspace, sites > 150t/d, 18% saving. Correspondingly the savings in airspace cost are estimated at similar orders of magnitude.

Minor savings on vehicle running costs are assumed. No firm evidence in the literature, therefore an arbitrary saving of 5% has been used in this study.

All other operating costs are considered unaffected.

	Daily Tonneage	25	50	75	100	150	200	250	300	350	400	450	500
	Summated Base Case (untreated landfill)	24485	27881	30972	34198	47231	51695	56527	69976	74630	79522	84066	88569
LESS	Airspace savings	(355)	(710)	(1065)	(1420)	(1775)	(986)	(1127)	(1690)	(1972)	(2254)	(2535)	(2817)
LESS	Site Vehicle Running Cost @ 5% of Base Case	(274)	(344)	(406)	(464)	(574)	(680)	(782)	(883)	(981)	(1078)	(1174)	(1270)
	Wet Pulverised landfill with on-site cover (excl. capital charges)	23856	26827	29501	32314	46030	50029	58436	67403	71677	76190	80357	84482
	Capital Charges (from Base Case)	7508	10395	14606	21660	28358	36408	36643	37975	40714	41957	47536	48718
	Wet Pulverised landfill with on-site cover (incl. capital charges)	31364	37222	44107	53974	74388	86437	95079	105378	112391	118147	127893	133200
	Rounded off total Wet Pulverised landfill with on-site cover	31400	37200	44100	54000	74400	86400	95100	105400	112400	118000	127900	133200
	Unit cost. Wet Pulverised landfill with on-site cover	5.02	2.98	2.35	2.16	1.98	1.73	1.52	1.41	1.28	1.18	1.14	1.07
	No Cover Operations - see comments for Dry Pulverised Refuse												
	Unit cost. Wet Pulverised landfill with no cover	5.02	2.98	2.35	2.16	1.87	1.61	1.43	1.33	1.22	1.12	1.07	1.01